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SULPHUR COMPOUNDS IN GAS.

Report of the Proceedings

BEFORE A

COMMITTEE OF THE HOUSE OF COMMONS

ON THE

CRYSTAL PALACE DISTRICT GAS

AND

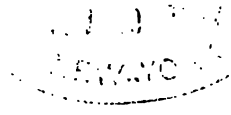
THE GASLIGHT & COKE COMPANY

BILLS.

SESSION 1877.

LONDON:
WILLIAM B. KING,
JOURNAL OF GAS LIGHTING, &c.,
11, BOLT COURT, FLEET STREET, E.C.

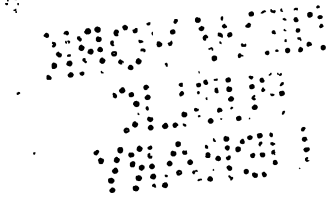
1877.



LONDON:

CLAYTON AND CO., TEMPLE PRINTING WORKS,

BOUVERIE STREET, FLEET STREET.



INTRODUCTION.

THE Bill promoted by the Crystal Palace District Gas Company, in the Session of 1877, had for its object the repeal of the 17th section of their Act of 1873, so far as relates to the maximum quantity of sulphur to be contained in the gas supplied by the company. That section requires that the gas "shall not contain more than 20 grains of sulphur in any form in 100 feet." The company are liable (under the 36th section of the Gas-Works Clauses Act, 1871) to a penalty of £20 for every day in which the sulphur impurity is in excess of the prescribed amount.

The Bill promoted in the same Session by The Gaslight and Coke Company sought to repeal sections 30 and 51 of their Act of 1876. Under section 30 of that Act it is provided that the Referees (appointed under the City of London Gas Act, 1868) shall, from time to time, ascertain with what degree of purity the company can reasonably be required to make and supply gas continuously, without occasioning a nuisance to the neighbourhood in which the works are situate, and shall thereupon prescribe and certify the maximum amount of impurity, in each form, with which gas supplied by the company shall be allowed to be charged. Section 51 enacts that if on an average of three days, the gas supplied by the company from any station is of less purity than it ought to be under this Act, the company shall forfeit a sum of £50 for each station in respect of which they are so in default.

Under the 30th section the Referees have fixed the maximum amount of sulphur allowable in the gas manufactured by the company at their Beckton, Bow, and Bromley works, at 15 grains per 100 feet in the summer, and 20 grains in the winter; for gas made at the other works of the company, at 20 grains in the summer, and 25 grains in the winter.

In the preamble of their Bill the company stated that the provisions of the Act of 1876 had been found to operate injuriously to the company, without securing any adequate advantage to the con-

sumers, and it was therefore expedient that the same should be repealed.

The arguments employed and the evidence given in support of both the Bills was to the effect that the purification of sulphur from gas to the extent required involved, first, the production of a nuisance in the neighbourhood of the works, and secondly that the retention of the amount of sulphur remaining after the ordinary modes of purification had been adopted did not result in any detriment to the consumers of gas.

On the other hand, the opponents of the Bills contended that gas might be effectively purified from sulphur without producing any nuisance in the neighbourhood of the works, and further that the presence of an excess of sulphur in gas was productive of damage to the consumers.

In each case the Committee declared the Preamble of the Bill not proved.

SULPHUR PURIFICATION.

HOUSE OF COMMONS COMMITTEE.

MR. R. D. PLUNKET, *Chairman;*
MR. FOLJAMBE, MR. STARKEY, *and* MR. COURTNEY.

CRYSTAL PALACE DISTRICT GAS BILL.

MONDAY, APRIL 30, 1877.

Mr. PHILBRICK, Q.C., Mr. MICHAEL, and Mr. PAULI appeared for the promoters; Mr. CRIPPS, Q.C., and Mr. O'HARA for the Metropolitan Board of Works, petitioners against the Bill.

Mr. O'HARA, at the sitting of the committee, applied that this Bill and the Bill of The Gaslight and Coke Company might be taken together, on the ground that the questions involved in each were similar. The object of the present Bill was to amend the 17th section of the Crystal Palace District Gas Act, 1873. That clause provided that the gas supplied by the company should not contain more than 20 grains of sulphur in any form in 100 cubic feet of gas. The promoters sought by this Bill to be relieved from that condition. The Gaslight and Coke Company by their Bill also sought to be relieved from a similar obligation under a somewhat different form. By their Act of last session, which revised many of the provisions of the City of London Gas Act, 1868, three gentlemen, called Gas Referees, were appointed by the Board of Trade, and it was the duty of these Referees to prescribe, from time to time, the maximum amount of sulphur impurity to be allowed in the gas supplied by the company; and to that duty was attached the condition that they should ascertain with what degree of purity the company could supply gas continuously without occasioning a nuisance in the neighbourhood in which their works were situated. But both Bills, though different in form, related to the question of the maximum amount of sulphur impurity to be allowed in gas. In the one case, the maximum amount was prescribed in the company's Act; and in the other, the amount was to be prescribed under special conditions mentioned in the Act. He (Mr. O'Hara) appeared with his learned friend Mr. Cripps in this case, and with Sir E. Beckett in the next, which was the larger case, and they were exceedingly anxious on this point. Of course an investigation like this involved the examination of scientific witnesses, and other persons whose attendance it was difficult to obtain,

and whose remuneration was a matter of great consideration to the Board and to the Corporation, for whom he appeared. He had, therefore, to ask the committee to allow Mr. Philbrick to open the case for the Crystal Palace District Gas Company, and, when the evidence on that Bill had been heard, the committee would suspend their decision until after they had heard the case of The Gaslight and Coke Company. He admitted that he was asking for a slight departure from the usual course, but he thought it was one which would be most convenient for the committee, and advantageous to the public.

Mr. MICHAEL said he appeared for the gas companies in both cases. It was not for him to dictate to the committee what course they should adopt, but he thought he could put before them some considerations to prove that it was not desirable to adopt the course suggested by his learned friend. Although it was quite true that the objects of the two Bills, so far as the sulphur question was concerned, were identical, the matters which the committee would have to consider, in coming to a decision on each, were as diverse as they could possibly be. In the first place, the area supplied by each company was essentially different; the one was suburban, the other was entirely metropolitan. Now the circumstances attending the production of gas and the dealing with the refuse products were in each case different. In the surrounding places the parties who appeared in opposition to the two Bills were quite different persons. In the case of the Crystal Palace District Gas Company, the Metropolitan Board of Works obtained a *locus standi* before the Referees, because the company, although not a metropolitan company, supplied gas within a small portion of the metropolitan area. In the case of The Gaslight and Coke Company, the Metropolitan Board and the Corporation appeared to oppose, and was it fair that the promoters of the first Bill, being a small company, should be put to the expense of attending before the committee, and waiting the whole course of the proceedings of a large company with immense revenues, and having a considerable number of witnesses to call in support of their case, when the question which the committee would have to decide was, as he ventured to assert, knowing the particulars of both Bills, entirely different in each? In the Crystal Palace District Gas Company's case, the question pure and simple was whether or not the restriction as to the quantity of sulphur other than sulphuretted hydrogen should be allowed to continue. In the case of The Gaslight and Coke Company there were complicated questions with reference to the duties of the Gas Referees. These questions did not affect or interest the promoters of the first Bill, as the Referees had no control over the gas supplied by them. In truth, what he considered the crucial point of the whole matter was this, that it did not follow at all that the decision in the one case would govern the decision in the other. The case which would be presented for the Crystal Palace District Company would be so placed before the committee that they would be able to come to a decision upon it without any reference to the circumstances which would be afterwards brought before them on the other Bill.

The committee having deliberated,

The CHAIRMAN said the committee felt that, though the parties had a right, according to practice, to have the two cases heard separately, they might, with a view to economize time and expense, hear the promoters of both Bills together, then take the opposition to the Crystal Palace District Company, and dismiss them from attendance, hearing the opposition to The Gaslight and Coke Company's Bill afterwards. It seemed a rather unnecessary expenditure of time and money that the cases of the promoters of the two Bills, if they were really and substantially the same, should be heard twice over.

Mr. MICHAEL said the committee would find they were entirely the reverse. Except the scientific portion, there was nothing in common.

Mr. O'HARA said he would then propose to his learned friend to take the larger case first.

Mr. MICHAEL declined to consent to such an arrangement, which he said would be grossly unfair. The witnesses for The Gaslight and Coke Company were not present, to begin with, and he was not prepared to go on with that Bill.

After some further conversation, the committee decided to proceed in the usual course with the first Bill.

Mr. PHILBRICK opened the case for the promoters. In doing so, he said: Sir, it devolves upon me to state to the committee the case of the first Bill before you, which is that of the Crystal Palace District Gas Company, and which is, as you have heard from my learned friend, Mr. O'Hara, a short Bill. It seeks to accomplish its object with singular brevity and directness —namely, to repeal a portion of section 17 of the company's Act of 1873, which restricts the maximum quantity of sulphur to be contained in the gas to 20 grains per 100 cubic feet, with the proviso that nothing in the repeal shall authorize the presence of sulphuretted hydrogen in the gas to be supplied to the consumers. Now, sir, from what has passed in a preliminary discussion, I am afraid that the committee may have formed the opinion that the matter embodied in this Bill is likely to involve considerations of a highly scientific and delicate nature. I think, if I am sufficiently able to explain that which, I trust, I in some measure appreciate myself, the matters in this Bill will not resolve themselves into any considerations of that kind, or involve such minute and delicate analyses as seem to be hinted at. If I shall be successful in conveying to the committee what has been brought to my mind, the matters that will have to be disposed of will depend not entirely on chemical or scientific results of analysis, but upon what I may rather call physical considerations; and if at all I venture, in the course of the remarks I am about to make, to describe the history of gas-making, the committee will understand it is simply for the purpose of enabling them to follow the evidence, and to bring it to a point at once, instead of troubling them with a great quantity of scientific analysis, and the results of rather elaborate tables, which have had to be gone through in order to get at what I shall be able to state briefly. I may mention at once that the position of the Crystal Palace District Gas Company differs entirely from that of the large companies, or rather large company who supply London. I say large company, because, practically, on the north side of the Thames there is but one company, The Gaslight and Coke Company, who, by a series of amalgamations and extensions, have become the great supplier of gas on that side of the Metropolis. We, the Crystal Palace Company, are situate on the south side, and we were originated and incorporated under a deed of settlement in the year 1854, shortly after the Exhibition was removed from Hyde Park to Penge. It so happened that in the year 1855 the Metropolitan Board of Works were organized and incorporated chiefly for the purpose of removing the sewage of London out of the Thames, and of constructing a large system of drainage for the Metropolis. In drawing the line for the metropolitan area to be under their jurisdiction, it was so drawn as to include a portion of the suburban district—about one-third of it—which was within the limits of supply of the Crystal Palace District Gas Company; and in that way, and in that way only, did we become, as it were, under the jurisdiction of the Metropolitan Board of Works. In 1858 we obtained parliamentary powers, and put ourselves under the Gas-Works Clauses Act of 1847. That Act is a general Act, which is incorporated in all Acts of gas companies throughout the country, and it contains a series of clauses applicable to such undertakings, framed much as the Lands Clauses, or the Police Clauses, or the Town Commissioners Clauses (which are general Acts) are framed. By those clauses, under which we were until the Act of 1873, we were bound to supply gas of not less than 12 candles illuminating power. We had a maximum price of 6s. per 1000, and under our Act we obtained power to raise our capital, subject to the ordinary restrictions—that is to say, our maximum dividend not exceeding 10 per cent. per annum. In 1865, our district having increased, we came to Parliament, and got powers to raise additional capital; and in 1873 we obtained a further Act, the 17th section of which we propose to partially repeal by the Bill now before the committee. The necessity for coming to Parliament in 1873 arose from the fact of the growth of our district, and our resources not being adequate to supply our consumers without a further expenditure of capital. We had at that time raised a considerable portion of our capital, not at 10 per cent., but at 6 per cent.; we had exercised our borrowing powers, and we had for years been doing that which

we have continued, thinking it the right course for the company, and a course the best adapted to our own interest and the interest of our consumers, all in the same direction—we have been, so far from charging our maximum price, keeping our price down—we were raising our capital only when compelled, and not raising it to the maximum amount of dividend which we were entitled to charge, so that in consequence we were supplying gas in the suburban districts practically as advantageously as gas was being supplied within the Metropolis itself; and in addition we were burdened with a very small capital in proportion to the amount of the district we were supplying, and the extent of the gas we were making. When we came to Parliament in 1873, the Metropolitan Board of Works appeared to oppose us, and what they wanted to do was to include us within metropolitan gas legislation, and to bring us to the level of a metropolitan gas company, putting us under the Referees and under the restrictions that were then in existence as to the metropolitan companies. You may, sir, perhaps know—but it is not for me to anticipate the case of The Gaslight and Coke Company—but you will certainly hear at great length, and I may state it shortly, that the metropolitan gas companies in the years 1868 and 1869 were placed under a tribunal called the Gas Referees, appointed by the Board of Trade. The gas was directed to be tested by a number of gentlemen called Gas Examiners, and the general provisions of the system of gas legislation then in force in the Metropolis involved a maximum price to be charged for the gas, with a power on the part of the companies to come before commissioners appointed by the Board of Trade to revise the price in case they desired to increase the maximum, and there was a similar power of revision, in the interests of the consumers, before the same commissioners, in case the consumers desired to reduce the price of the gas. The commissioners were a body who have since become extinct. They were to consist of an accountant, a gentleman practically versed in gas manufacture, and a barrister, who presided as chairman. My learned friend, Mr. F. S. Reilly, presided; Mr. Pattison was one of the commissioners, and Dr. Odling was the third commissioner. That system was alleged by the Metropolitan Board of Works and by the Corporation to work to some extent prejudicially to the interests of the consumers; and in the year 1875 a very lengthened investigation took place in Parliament before a committee, of which Mr. Forster was the chairman. The result of that inquiry was that, although no legislation took place with regard to The Gaslight and Coke Company, certain principles were arrived at which formed the basis of an Act then passed, affecting only the Commercial Gas Company; and, in 1876, these principles were embodied in an Act affecting The Gaslight and Coke Company. But these provisions and the whole of that legislation were applied to the Metropolis properly so called, and never touched and never affected the Crystal Palace District Gas Company. In 1873 it was desired by the Board of Works to include us within their limits, and subject us to metropolitan legislation; but after some considerable discussion, the committee thought we were not a company falling within the purview of that legislation, that we were exceptional, and that our case depended entirely upon its merits, and they excluded us from the operation of metropolitan Acts. The chairman said: "The opinion of the committee is that each of these companies as they come before Parliament ought to be taken upon their merits. This case is not to be taken as a precedent with reference to any of the metropolitan districts. It is one which the committee have thought exceptional, and depending entirely upon its own merits." So that the attempt of the Metropolitan Board of Works to subject us to metropolitan gas legislation entirely failed. The question was then set at rest—and I think I may say set at rest for ever—that we were not a metropolitan company, but were to be dealt with like other gas companies.

Mr. CRIPPS: I assume my learned friend would not state this unless it had some bearing, and if it has, it has some importance; the fact is, the committee did not decide whether they were within or without these obligations, but that it was a case to be taken by itself. Some of the regulations, or a great many of them that applied to the metropolitan companies, were put in, and others were left out.

Mr. PHILBRICK: My learned friend, Mr. Cripps, did not follow me. I read the exact words that fell from the chairman.

Mr. CRIPPS: Then you went on to say that you were entirely excluded from the legislation of the Metropolis?

Mr. PHILBRICK: I say we were not included in the general Acts of the legislation of the Metropolis. In the Bill, however, which we brought forward at that time, and which was principally a money Bill, we said that we were willing to give the consumers the benefit of an increased illuminating power in the gas. I have told you that we were under the Gas-Works Clauses Act of 1847, with a limit of 12 candles; but we then volunteered to place ourselves under an obligation to supply 14-candle gas. That was a voluntary obligation undertaken by us. The 17th section of our Act then provides—"And such gas shall not contain more than 20 grains of sulphur in any form in 100 cubic feet of gas." Those words we are now proposing to repeal. I will just tell the committee how they came to be in that Act. In the cross-examination of Mr. George Wilson Stevenson, the very eminent gas engineer, who was a witness for the promoters of that Bill, he was asked whether there was any clause in the Bill, as then introduced, as to purity—that is page 25, question 151. It was an immaterial question, because I think I was then representing the Metropolitan Board of Works, and it was a question that fell from me:—"By the by, there are no clauses in the Bill as to purity, are there? (A.) I think not; I do not remember that there are.—(Q.) Nor are there any in the Act of 1871, are there? (A.) Yes.—(Q.) Except as to sulphuretted hydrogen? (A.) Yes.—(Q.) Not as to sulphur or ammonia, nor any product of sulphur, except only as to sulphuretted hydrogen? (A.) Just so. I think it is quite right that there should be clauses inserted to protect the consumer from an undue amount of sulphur and ammonia." And there I left it. That was Mr. G. W. Stevenson, who was a witness on the part of the promoters of the Bill; and when he came to be re-examined by my learned friend, Mr. Horace Lloyd, he was asked this:—"At present they are under no test for purity, and you say there is a test for sulphuretted hydrogen by the Act of 1871? (A.) Yes.—(Q.) You think there should be one as to sulphur. (A.) I think there should be one as to the maximum of sulphur.—(Q.) What quantity of sulphur? (A.) I think 20 grains. The promoters have not consulted me upon that point at all. I think it is quite right." Upon that the 20 grains were put into the Bill in the shape in which it is now an Act; and it is because we have found that that which was then supposed to be an ordinary limit which might fairly be fixed, and which would be carried into practical working in the manufacture of gas, without either nuisance, or incovenience, or undue expense, is intolerable and almost impracticable, and produces no useful result at all to the consumer, that we are here asking Parliament to remove that restriction as to the sulphur compounds. Now, sir, having told you how and why it came into the Bill, there being no restrictions before, I shall trouble the committee with a few observations as to what these sulphur compounds are, and how they come to be present in the gas which is manufactured for commerce. Roughly speaking, the manufacture of coal gas is carried on by distilling the coal in sealed vessels called retorts, exposing them for some time—six or seven hours—to a bright red heat, the effect of which is to send off a portion of that which is within the retort in the shape of volatile matters, leaving behind the residuum, which we all know as coke. These volatile matters, the product of distillation, contain tar and ammoniacal liquor, which, the moment the vapour cools, condense and become liquid; but in the gas which remains there are certain foreign substances—perhaps I may call them impurities—and those impurities may be classed as follows:—One is ammonia—there is a large quantity of ammonia; secondly, there is a large quantity of carbonic acid; thirdly, there is sulphuretted hydrogen; and fourthly, there is the presence of what are called "other sulphur compounds," which are not exactly determined by the resources of chemistry up to the present moment, but which are known as sulphide of carbon. The ammonia in the gas is partly extracted; its presence can be detected exceedingly easily by litmus or turmeric paper—that is one test for it—and it is removed from the gas by the processes called washing and scrubbing, to which the

gas is subjected—that is to say, by treating it with water in certain vessels called washers and scrubbers. The presence of ammonia is not objectionable in one respect; but it is objectionable to gas manufacturers, because its presence tends to decrease the illuminating power. If you get a large quantity of ammonia in your gas you get less illuminating power, so that if you have an excess of ammonia, what you have to do is to put more cannel into the retort, and thus increase the lighting power of the gas. Ammonia itself is productive of no particular nuisance. The presence of carbonic acid is very easily ascertained. You have only to take a little clear lime water, send the gas through it, and if there is carbonic acid you turn it milky white, and make the water quite cloudy—that is very easy, and there is no difficulty at all in removing it. Then there is the sulphuretted hydrogen. Now, sulphuretted hydrogen, as we all know, is an exceedingly foul and offensive gas. It is a gas which, wherever it exits, creates great nuisance and inconvenience, and while it is always present in crude gas as manufactured and produced in the retort, it never is, or never ought to be, present in the purified gas delivered to the consumer. It can be got rid of by proper means of purification, and practically it always is got rid of; so that that remote quantity which an analyst calls a trace—which, I believe, means, in chemical language, enough to satisfy him that it is there present, but in a quantity which is inappreciable—does not exist, or scarcely ever exists in the gas as it is delivered to the consumer. It can be removed, or used to be removed, by lime; but some years ago it was discovered that a substance called hydrated peroxide of iron, under proper conditions, entirely absorbs the whole of this deleterious sulphuretted hydrogen, and when the gas is purified by the process of the peroxide of iron, the sulphur becomes precipitated in it, or, rather, comes into it in a solid form, and I believe modern science has shown a means of extracting it from the oxide, so that the oxide becomes available for use again, and chemists have shown the manufacturers how to avail themselves of the sulphur thus extracted from the gas. Now, sir, I have dealt with all the impurities found in the gas delivered from the purifiers, except the sulphur products other than sulphuretted hydrogen. Those sulphur products were discovered by Dr. Letheby some 20 years ago, though their existence had been suspected for some time. They are impurities which are not discoverable in crude gas, but which are given off only when the gas is burnt. Suppose you were to allow the gas to escape from a pipe, you would not detect them, or could not detect them chemically then. The only way in which, up to the present moment, they have been detected chemically, I believe, is by burning the gas at the rate of half a foot an hour for 20 hours in a closed chamber that contains the products of combustion. You will then find that there is undoubtedly present sulphide of carbon—that is the name given to it for want of a better distinction—and this body, and this body only, is that which is designated "other sulphur compounds" in the gas. It necessarily arises from the combustion of ordinary coal gas, and I believe that, as a matter of fact, between 30 or 40 grains—some 33 grains—is about the average in gas which is not purified from this substance. Now, sulphuretted hydrogen, as it is always a nuisance, is prohibited in various gas Acts, but to this day, except in the Metropolis, and a few places in the country, there is no limit and no restriction about these other sulphur compounds in the gas. At Birmingham and Manchester, and other great towns in the kingdom, where the municipalities supply their own gas, they are absolutely without limits in this respect. Paris, which is most particular, and where the most exhaustive scientific experiments have been made with regard to the presence of, and the alleged deleterious effects of these sulphur compounds in the gas, is also without a restriction. But in London the Referees have a power, within certain limits, to say how much of these "other sulphur compounds" shall be present in the gas. They have power to fix it between 30 grains and something less, but we are put—and I believe we are the sole instance almost in the kingdom (there may be two or three other cases)—we are put under the hard and fast line of 20 grains per 100 cubic feet of this impurity. I hope the committee will pardon me if I venture to call their attention to the extremely inappreciable quantity of this impurity in the gas. You see, if

you turn to it at once, how misleading the matter really is—it is 20 grains (that is weight) per 100 cubic feet (which is volume), so that you are comparing weight with volume. It would be a much fairer comparison, I think, if you compared volume with volume, or weight with weight. Now, let me see what it is. One hundred cubic feet of gas weigh, taking it at the ordinary specific gravity, 22,500 grains, and the 20 grains of these "other sulphur compounds" that are allowed by the 17th section occupy ·0088 foot—that is, $\frac{88}{10000}$ths of a foot. Increase it to 40 grains and it is ·0018, or $\frac{18}{10000}$ths; which, of course, is almost inappreciable. I have stated it by weight. Now let me state it by volume. It would be 5 cubic feet in 10,000, or 1 in 2000. But now suppose there were 40 grains, which is the maximum almost that has ever been found after a large number of testings. These products, as I have told you, are only to be detected when the gas is consumed by combustion, and when the gas is so consumed they become a double quantity—that is to say, they produce 80 grains of sulphurous acid gas per 100 cubic feet, or just 1-15th portion of one cubic foot. So that to get one cubic foot of sulphurous acid gas, which will go easily into the crown of a man's hat, I have to burn 1500 cubic feet of the gas supplied. Now, when I have burnt 1500 cubic feet of the gas supplied as a necessary consequence of the combustion, it produces two things—vapour and carbonic acid; and, necessarily, the 1500 cubic feet of gas would produce 1000 cubic feet of carbonic acid, so that my one foot of sulphurous acid and vapour is diluted with 1000 times its volume of carbonic acid gas. Now there is another fact I may mention which may be known to you. An ordinary adult human being respires carbonic acid gas which is equivalent to two ordinary 3-feet gas-burners; and in the most crowded theatres, where the atmosphere has been analyzed, the amount of carbonic acid discovered by analysis is 0·32—rather less than a third—per cent.; and now what I have mixed with that quantity I have to divide by 1000, before, at 40 grains of sulphur impurity per 1000 feet of gas, I get any product of combustion that can possibly even include sulphur, whether deleterious or not. So you will have, from the most exact scientific evidence, that, even under the most unfavourable conditions, I have got it mixed with 1000 times its volume of carbonic acid, and I have got the whole of that in the proportion of one-half millionth in the volume of the atmosphere, and that is the worst result there possibly can be. Taking the maximum of carbonic acid that has ever been discovered under such unfavourable circumstances as I have mentioned, you are dealing with a matter which is so inappreciable as to be positively one half-millionth of the volume. If I have made these figures clear to you—and they will be spoken to by a very eminent gentleman indeed, Dr. Odling, whose calculation it is really (and he is one of those commissioners that we have heard mentioned, appointed as practically conversant with the make of gas)—if I have brought it home to you, the committee will see how small a quantity it is that we are dealing with—utterly inappreciable, you will find. I will not now detain you by going into other calculations, but I may state that we have had experiments made. There is one company in London who have always been held up as a model, and they have been to some extent a terror to other companies. They have been fortunate in having one of the ablest gentlemen connected with the manufacture of gas, taking an active part in the management; I mean the South Metropolitan. That company have supplied pure gas cheaply, and have carried out the process of gas manufacture so well as to be held up as the good child whom all others are to copy as an example. Mr. Livesey, the manager of those works, placed a room at the disposal of some eminent chemists whom I shall call before you, and in that room was burnt gas manufactured by his company, which had not been purified from any of the sulphur compounds, and contained between 33 and 35 grains per 100 cubic feet of them. That room was an ordinary room; it had a door, a fireplace, and two windows, and the gas was burnt there for hours, and, after about six hours of burning, the maximum amount of sulphur impurities found in the atmosphere, whether or not the burning were continued for a greater or less time, was this—it showed substantially this, that in an ordinary room where gas is burnt you may divide the atmosphere into three zones. There is one about 18 inches from the ceiling, caused by the heat of com-

bustion, and is about 20 degrees above the ordinary temperature of the room. After about five or six hours burning the hydrometric conditions there are bad, and the bulb of the thermometer is very dry. At 18 inches down from the ceiling to about 5 feet six inches, or something of that sort, which is about the height of an ordinary individual, is the middle or temperate zone; and at 18 inches from the floor there is a third and distinct condition of the atmosphere. In the middle zone, in the most unfavourable conditions, burning gas without these impurities extracted, you would have to be shut up as close as possible, and have to respire that atmosphere, and nothing else, for five or six hours before there could possibly enter into the system one-tenth of a grain of sulphurous acid gas. Well now, sir, it may be common knowledge to all of us—certainly, if I may venture to say so, it was brought home to me personally in a peculiar manner—that the burners which are employed in our houses do not consume all the gas, and that a great deal of the annoyance found from the ordinary domestic use of gas is because a great quantity of the gas that is delivered from the pipe escapes into the atmosphere of the room without being consumed. I have heard in these rooms, over and over again, by scientific witnesses, that a perfect burner, if you can get it—an ideal model burner—is so to regulate the combustion of gas behind it, that, at the point of combustion, where the spark comes to the gas, you have no pressure; that is to say, that the flame consumes all the gas as it is delivered, and none escapes into the atmosphere unconsumed. As to any of these sulphur compounds that escape into the atmosphere unconsumed, there positively is no question, and could have been no question, because they cannot be detected even by analysis, and it cannot be suggested that they cause practical inconvenience to a single human being, or damage to a single farthing's worth of property. All these calculations I have been giving you, and all these minute quantities, are upon the supposition that the gas is absolutely and perfectly consumed, which we know it really is not. But if you take into consideration that in all places where gas is burnt, where the ventilation is good and sufficient, there is positively no inconvenience felt, and the presence of these sulphur compounds cannot be detected, or, if detected, only in the minute proportion which chemists call a trace; so that, if gas is burnt under ordinary and fair conditions, the presence of these sulphur compounds is absolutely immaterial, and if it is burnt even for the purpose of satisfying the chemist as to what amount of sulphur he possibly can get, it comes to so small a proportion as to be practically inappreciable. Still, although most minute, if it is noxious and hurtful, it should be removed at any cost, if it can be. But I state broadly, in the presence of those in authority (the Metropolitan Board of Works here), that the researches of chemistry show that even in a laboratory test you cannot remove it. It is utterly impossible to remove; and, in the practical working, such as is necessary in the manufacture of gas, all that you can do, by the best means at present devised by the most eminent chemists, is to take out from something between 30 to 40 grains per 100 cubic feet of gas, so as to reduce it to something under 20 grains. That is all you can do. You can remove from one-fifteenth to one-tenth of the quantity there present. Now, in order to do that, let me tell you what is to be done. You have to resort to lime purification. Formerly all gas was purified by lime. When the properties of oxide of iron were discovered, it was had recourse to, partly only at first, because there was a patent, and it was protected by royalties, out of which arose litigation. But the result of working by lime is this: In removing the impurities of gas, the lime employed becomes exceedingly foul and exceedingly offensive. The ordinary way in which purification is accomplished is first to pass the gas through purifiers, in which the lime is put on trays. You take out the carbonic acid by the first, and by the second you take out the sulphuretted hydrogen. It has been found that, after this, the objectionable bisulphide of carbon, or sulphide of carbon, exists in the gas, and the only way of removing the small quantity that practically can be removed is to expose the gas to the action of dry lime already saturated with sulphuretted hydrogen. First of all the gas is passed over the lime, to remove the sulphuretted hydrogen, and then the lime, which is thoroughly saturated with sulphuretted hydrogen, and is in the foulest and

most objectionable condition that it possibly can be, has a chemical affinity for these "other sulphur compounds." But, in order that it may thus act upon the "other sulphur compounds," you have to keep it in this foul and highly objectionable state, and when, ultimately, you discharge these lime purifiers, you create an enormous nuisance in the neighbourhood—I say nothing of the men.

The CHAIRMAN: Will you allow me to interrupt you? I thought you spoke of a second tray of lime, by which the sulphurous particles were extracted, but now I think you say it is the same.

Mr. PHILBRICK: No; the first purifier removes the carbonic acid, the second the sulphuretted hydrogen. If you will allow me, I will just mention how it is done. I think there are two vessels, which are lime purifiers, and which have trays of lime in them—several trays of lime in each. The lime is spread so as to afford the greatest amount of surface for the gas to travel over. The first of these processes adopted by us removes the carbonic acid, and the second removes the sulphuretted hydrogen, and being saturated with it, it acts upon these other obscure sulphur compounds. Then a third tray is filled with the oxide of iron, and that removes the residue of the sulphuretted hydrogen; and we must do that, because, keeping the second tray charged to the full, saturated with sulphuretted hydrogen, it does not remove any of the sulphuretted hydrogen that after that period of saturation passes over it. If once you have got it fully saturated, then all it does is to take the other sulphur compounds, and you must treat it with oxide of iron afterwards, to get the sulphuretted hydrogen from it. I say nothing of the offensive nature of the lime which has to be removed from that purifier by the men; it is difficult to get them to do it—the suffering they have to undergo physically is very great; but the nuisance to the neighbourhood is something tremendous. It is naturally complained of wherever it exists, and it is so great that the lime process of purification cannot practically be resorted to in any crowded city, or near any city. But further than that, I ought to mention that there is a most expensive process resorted to by this particular company, in order to get rid of these other sulphur compounds. We can get rid of all the other impurities, but since the presence of these other sulphur compounds has been restricted, the effect upon this company has been to add as much, I think, as 2d. per 1000 cubic feet of gas to the actual cost of production, during the three years which have elapsed since the Act of 1873 has been in force; and when we have studiously endeavoured to carry out the requirements of the Legislature, it has averaged over a penny. But during the last year the necessity for the extended use of the lime has been so great that it certainly costs the consumer 2d. at least per 1000 feet more for gas, and in actual amount of cost in the purification you will find that it really costs us, per ton of coal carbonized—which is the unit that they use in gas manufacture—5d. more; the figures are 2¾d. (I am not going to decimals) as against 7¾d.; and, in addition, we have this foul compound, the very presence of which is a nuisance, and the removal of which is complained of by the neighbours and the neighbourhood at large, and we have to pay for removing it. It has to be carted or taken away by truck, and I believe it is useful for no purpose whatever. The lime can only be used once, and when once it is fouled it is got rid of as an offensive compound. I believe, in the case of the Chartered Company, they send it out to sea at a vast expense; but I will not anticipate their case. We have to get ours taken away; and it costs us 5*s.* a ton to get it taken away into the country, and that entails a charge which is of considerable importance—something like £250 to £300 a year. Let me be very frank with the committee, as far as I can, in this matter. I agree that these sulphur compounds are objectionable, and, if we can get rid of them, they should be removed; but the question is, what harm do they do? what is the cost of getting rid of them? and what is the necessity for removing them? and what is the trouble they cause? Let me tell you, as far as we can ascertain, it never has been alleged, even by Dr. Letheby, who discovered its presence, or by any of the eminent chemists or gentlemen who have been consulted on the point, or who have given their attention to the matter, that, with regard to the health of the community itself, the presence of this infinitesimal quantity is at all objectionable or deleterious. That never has been alleged.

The CHAIRMAN: Do you mean the 20 grains, or the 30 grains, or the 40 grains?

Mr. PHILBRICK: Even 40 have never been alleged to be injurious. I desire to adhere to the largest number at once. It has never been alleged that the presence of those other sulphur compounds has been at all objectionable, and I should be much astonished to hear it alleged in this committee-room. I do not think it can, in the face of all the scientific knowledge which has been applied to this subject. It is said that the choky sensation of an ill-ventilated room where gas is burning under proper conditions is due to these "other sulphur compounds." That is absolutely without proof, and is insusceptible of proof; it is only carbonic acid and the perfect combustion of gas. The carbonic acid being produced by the burning of gas gives rise to that sensation of heat and *malaise* that one feels in a badly-ventilated room. But then it is said that it destroys and tarnishes the gilding of rooms, the gilding of mirrors and picture frames, and the picture-rods round the tops of the rooms, and so on. All I can say with regard to that is this—and you will have positive evidence upon that point—that it is the heat in the air that I referred to, which generally causes the rot of the gilding of rooms, and the nuisance which is occasioned by the gilt tarnishing in the upper portion of the room. If any of the members that I have the honour to address may recollect, there was a great question some years ago about the library of the Athenæum Club, which is a room lighted with gas, and I believe there is a library in that building also, in which books are stored, which is not lighted with gas—that is to say, in which the products of the combustion of gas do not come into the room itself. I think it is shielded off with glass shields, as I believe the gas is in the House of Commons; but it was discovered in the library of the Athenæum that the maximum amount of injury that had been caused was all in a certain portion of the bookcases; and when Mr. Layton, the eminent builder, went to examine, he found that the flue of the kitchen chimney went up there, and that, almost entirely, the bulk of the mischief was in the books where the heat went. He could trace the course of the chimney by the leather of the books having perished. Well, but it has been said: "Oh, in other cases sulphuric acid has been found." Now, sulphuric acid, or oil of vitriol, is a very objectionable thing, and I am told (I am not chemist enough to understand it practically myself) it can always be produced where you have sulphur and water and combustion under certain conditions. I believe, in any very large city where coal is burnt, there is a trace, more or less, of sulphurous acid, and, sometimes, sulphuric acid; but that there is any sulphuric acid in these sulphur compounds I believe will be denied. It has been said that when you see the binding of a book perished you can taste the acid with your tongue. It is a most amusing thing if that be so, because practically in bookbinding they do use acid for the purpose of bringing about on the leather certain colours, applying certain pigments to them as mordants, and certain other books which were said to be affected and prejudiced did not contain a taste of acid; so that, in all probability, the acid which was supposed to have been detected would be rather that which was used in the original binding of the book. Otherwise, there is no reason why Gibbon's "Decline and Fall" should exhibit the acid, while Macaulay's "History of England," side by side, should not have the acid. Under these circumstances, we believe most thoroughly, from all our inquiries, and all the evidence we can produce, that there is really not a shadow of mischief to be attributed to this sulphur compound. People did not know what it was, and, therefore, they were afraid of it. Not the slightest injury can be alleged from the production of those sulphur compounds, even 40 grains in 100 cubic feet of gas. The mischief done is infinitesimal, and the labour, trouble, expense, and annoyance of creating a nuisance to the neighbourhood by the use of lime are so great that we feel that the restriction put into the Act in the way we describe would never have been there had all these facts been known, and had due consideration been given to them. We shall call Mr. Stevenson before you, who will explain his views. He is not ashamed to say that, having bestowed further attention on it, he is convinced that there are really not the slightest injurious effects produced by the presence of these sulphur compounds, and we shall ask the committee,

when they have heard the case, to relieve us from this obligation, we at the same time putting ourselves under the limitation that in no case shall the sulphuretted hydrogen which is objectionable be present in the gas which we deliver to our consumers.

Mr. *George Livesey*, examined by Mr. PAULI.

I am a member of the Institution of Civil Engineers, and Past-President of the British Association of Gas Managers. I am engineer and secretary of the South Metropolitan Gas Company, and also a director of the Crystal Palace District Gas Company. In the manufacture of gas, the raw material—the coal—is placed in a retort, which is heated to a bright red heat, and the result is that the volatile matters are driven off by the heat, the volatile matters consisting of condensable tar and water, and other matters consisting of the illuminating gas and certain gaseous impurities, such as sulphuretted hydrogen, ammonia, carbonic acid, and other sulphur compounds. The coke is left in the retort, to be drawn at the expiration of five or six hours, when the gas has all been expelled, and the tar and water are condensed by simple cooling—by simply carrying the gas through a pipe exposed to the air, or carried under water. In this way they are removed mechanically. We then have to remove the gaseous impurities, which consist of ammonia, carbonic acid, sulphuretted hydrogen, and other sulphur compounds, which are principally sulphide of carbon. The ammonia is first removed, and, owing to its extreme affinity for water, it can be very readily removed by bringing it into contact with water only. The sulphuretted hydrogen—which is the most objectionable impurity, and, in fact, such an objectionable impurity that if it were left in the gas it would render the gas totally unfit for burning, and totally intolerable—was removed originally by the use of lime. Up to about 1850, or a little later than that, all the gas-works employed lime for the removal of sulphuretted hydrogen. This lime, when taken from the purifiers absorbed carbonic acid from the air, and sulphuretted hydrogen was evolved, causing a very objectionable stench in the neighbourhood. I lived near the gas-works—on the premises, in fact—in those early days, and can remember very numerous complaints that were made respecting this lime. In 1850, or thereabouts, it was discovered that sulphuretted hydrogen could be most effectually removed by means of hydrated peroxide of iron—a material which not only absorbs the sulphuretted hydrogen with great readiness, but also renders it perfectly innocuous. This material, on being taken out of the purifiers, is exposed to the air, and by that exposure it absorbs oxygen, which causes the sulphur or sulphuretted hydrogen which had been combined with it to be deposited as sulphur in a solid form. Exactly the reverse of that was the case with lime. The sulphuretted hydrogen by the lime process is driven off into the air; but with the oxide of iron process it is deposited in the solid form; and this oxide of iron, after a few days exposure, becomes what we describe as revivified, and fit for use again, and so can be used over and over for perhaps twelve months. The sulphur is not absolutely separated from it. We start, say, with 100 cubic yards of oxide of iron. Some of it is got from the bogs of Ireland, and some of it is artificially prepared. By putting it in the purifiers it absorbs a certain amount of sulphuretted hydrogen; then on exposure to the air that sulphuretted hydrogen is decomposed, and solid sulphur is deposited in the material. We then put it into the purifiers again and again and again; and at the expiration of about twelve months the 100 cubic yards become converted into 200 cubic yards. We then sell it to the sulphuric acid makers, who use it for making sulphuric acid, instead of purchasing sulphur or pyrites.

Mr. PAULI: I believe the removal of this sulphide of calcium is attended with considerable expense?

Witness: A very great expense. It costs the Crystal Palace Company 5s. per ton of coal carbonized. They have tried various means of getting rid of it, and after being complained of by the neighbours and the local authorities, creating a nuisance by depositing it either on their works or in other parts, they have been obliged to send it away by rail at a cost of 5s. per ton. A further impurity is carbonic acid, which has this effect,

that it diminishes the illuminating power of the gas—it has no other detrimental effect; but it may be advisable, in certain cases, to remove it by lime, or to substitute the use of a little cannel coal, which yields a richer kind of gas, and so brings up the quality. We may remove the carbonic acid, or we may increase the quality of the gas, and the result is the same. There is now a better plan of removing it than by the use of lime. Mr. Hills has invented a means of rendering the ammonia water caustic, converting the ammonia water from its crude state into a state of caustic ammonia, and this can be used, and is used by me at the South Metropolitan Gas-Works, for removing carbonic acid. This does not affect the sulphur question. It will ultimately affect it. The carbonic acid will bear very materially, ultimately, upon the sulphur question.

Mr. PAULI: Have you had practical experience of the nuisance of emptying these purifiers?

Witness: Yes, I have had, all my life, except when we used oxide of iron only. The nuisance is experienced a considerable distance from the works. I smelt it yesterday morning half a mile from our works in the Old Kent Road; commonly it extends further than that.

Mr. PAULI: With regard to the presence of ammonia, there is no difficulty whatever in ascertaining the existence of that?

Witness: It is just one of the simplest things possible. I have here, in this little case, a test for ammonia and sulphuretted hydrogen. It is simply a piece of blotting paper, saturated with acetate of lead; by wetting it, and exposing it to the gas, it will detect an infinitesimal quantity of sulphuretted hydrogen—considerably less than one grain in 100 feet of gas. This yellow paper is a paper saturated with turmeric, and by exposing it to the gas, it will detect as small a quantity as two grains of ammonia in 100 feet, by turning red. So that the test for those impurities is of the readiest and most sensitive character, and can be applied at any moment.

Mr. PAULI: And for carbonic acid the test is equally simple, I believe?

Witness: For carbonic acid a little clear lime water is put into a small vessel, and the gas allowed to bubble through it for perhaps a minute; and if carbonic acid is present, the water becomes cloudy.

Mr. PAULI: With regard to those other sulphur compounds in their gaseous state, can their presence in the gas be detected?

Witness: There are no direct means of testing for those other sulphur compounds. The old plan was to burn a jet of gas under very peculiar conditions for perhaps 20 hours, and condensing the products of combustion with an alkali. The products of combustion were then analyzed for sulphur. It was a very long process, and we are indebted to Mr. Vernon Harcourt, one of the Referees, for a much simpler means. This, however, is not a direct method. By heating the gas to a certain temperature—I do not know the exact temperature, but perhaps 400° or 500°—he converts the sulphur compounds into sulphuretted hydrogen, and then by testing with this lead paper, he can detect their presence. The tests for ammonia, carbonic acid, and sulphuretted hydrogen are absolutely reliable—perfect you may say; but the same cannot be said of the test for the other sulphur compounds. Those tests seem to vary in a most unaccountable manner. I may give an instance of tests made at different places upon the same gas, tests made about six weeks ago at the South Metropolitan Works, and the tests made by the official tester. We had 29 grains in 100 feet at the works, and the official tester gave a return of 42. I can only account for the difference (and other experience has gone to prove the truth of this) by the possibility of these sulphur compounds being absorbed or arrested, by accidental causes for a time, by the pipe through which the gas flowed, and then, under other circumstances, being carried on by the gas. And a further proof of that is this. For the purposes of this inquiry I had a special quantity of gas made and purified by oxide of iron only—that is, purified from ammonia, sulphuretted hydrogen, and partially from carbonic acid; but the sulphur compounds were left untouched. That gas was stored in a separate gasholder, to the extent of about 400,000 feet. Dr. Odling and Dr. Russell have been making experiments on that gas during the last three months; the gas has been tested daily for sulphur compounds; one day it would be 26 grains, and another

day it would be 39. I therefore thought that the great length of pipe through which it travelled—namely, 200 feet—might be the cause of it, and I had a pipe put direct into the gasholder and conveyed into the testing-room, and then I found there were variations, not to so great an extent, but very nearly; and the only conclusion I can come to is this, that the pipe absorbed or arrested something of the sulphur on some days, and gave it up on others. It was found uniformly to be the case that when the flow of the gas through the pipe was at the rate of half a foot an hour, the results were small—about 30 grains, or perhaps a little less; but that when the flow of gas through the pipe was at the rate of 15 or 20 feet an hour, we got 35 to 39 grains.

Mr. PAULI: Have there been any cases in which companies, without the use of lime, have attempted to purify their gas from the other sulphur compounds?

Witness: There have been numerous attempts made to purify it, but they have all failed; nothing but lime will do it at all.

Mr. PAULI: Is it correct to say that you cannot attempt even to purify gas from the other sulphur compounds without the use of lime?

Witness: Undoubtedly.

Mr. PAULI: And it is equally undoubted that you cannot use lime without being a nuisance?

Witness: It is undoubted.

Mr. PAULI: And I believe in those cases where it has been attempted without the use of lime, to purify the gas from sulphur compounds, it has only been done with a certain class of coal at a greatly increased cost?

Witness: There have been instances where companies have supplied gas containing a comparatively small quantity of sulphur without the use of lime. For instance, at the late City Gas-Works, Mr. Mann, the engineer, for a number of years maintained his sulphur at something very little over 20 grains in 100 feet, and even then there were the same discrepancies of testing. Mr. Keates tested for the company on the works, and Dr. Letheby tested for the Corporation in the City; and I believe their results never agreed. But it is possible to get a coal which yields a comparatively small amount of sulphur compound. On one occasion the South Metropolitan Company got a coal of this sort, and used it for twelve months. The quantity of sulphur amounted to not much over 20 grains, but the yield of gas was 900 feet per ton less than from the ordinary Newcastle coals. Moreover, the collieries which supply the coal yielding this small quantity of sulphur are so few and so small that it is absolutely impossible to get that coal as a general thing.

Mr. PAULI: Is it a fact that, where lime is used, in many cases the lime will give out the greater part of the sulphur that is previously absorbed?

Witness: That is just what it does do on exposure to air.

Mr. PAULI: Will you tell me about the discovery of these sulphur compounds?

Witness: A little over 20 years ago, I believe, they were absolutely unknown, and their existence was unsuspected until something like 20 or 25 years ago. Dr. Letheby, after being appointed by the corporation as analyst of their gas, discovered, by analyzing the products of combustion resulting from gas, that there was a certain amount of sulphur that was undetected by ordinary tests.

Mr. PAULI: Then, I believe, after his discovery, which was published there was a kind of panic among gas consumers; they had an idea that they were all being poisoned by some unknown compound?

Witness: I suppose they did; at any rate, there was a great deal made of it; and, of course, it being perfectly well known that in a room lighted with gas there is a certain oppressiveness felt, and a certain disagreeableness in the air, the conclusion was jumped to that it must be these newly discovered sulphur compounds.

Mr. PAULI: And was it this outcry against sulphur compounds which induced the Legislature to inquire into the matter, and to try and fix some maximum?

Witness: By the Metropolis Gas Act of 1860, the Legislature imposed a limit of 20 grains upon the companies, and, in fact, took "a leap in the

dark." Nobody knew how to deal with it; and that Act to the present day is a dead letter. Three of the large companies, supplying nearly all the south of London, are under that Act at this very moment, and the vestries and parishes who have had authority to enforce the Act have never done it. They are the Phœnix, the London, and the Surrey Consumers.

Mr. PAULI: Now, the process of purification that you use is practically Mr. Patterson's, is it not?

Witness: The certain means of dealing with the sulphur compounds by means of lime is undoubtedly Mr. Patterson's plan. The old plan was to use oxide of iron in one set of purifiers—four purifiers, for instance—through which the gas passed in succession, in order to be perfectly secure that the gas was thoroughly purified. In order to deal with those sulphur compounds, you must have three sets of purifiers instead of one set. We are indebted to Mr. Patterson, one of the first Referees, for making it clear, and Dr. Odling also investigated the same thing about the same time. You must have one set of purifiers to remove all the carbonic acid, and another set of purifiers also charged with lime to absorb first the sulphuretted hydrogen, and then, when this lime has become saturated with sulphuretted hydrogen, it is in a condition to absorb the sulphur compounds. Then you must have a further set of purifiers to absorb the remaining sulphuretted hydrogen. When the lime is in the condition shown in the specimen produced, it is in a fit state for absorbing the sulphur compounds. That lime is saturated with sulphuretted hydrogen. This bottle contains some of the oxide before it is exposed to the gas. The other contains the same oxide which has been taken out of the purifier after purifying the gas. If this were spread out and exposed to the air for a few hours, it would become a brown colour, and ready for use again. This abominable stuff [pointing to the bottle containing foul lime] is of no use. There is a little smell from the oxide when the purifier is being emptied, but nothing appreciable.

Mr. PAULI: Just explain to the committee for one moment the difference between the purifiers with sulphide of calcium and oxide, when both are impregnated with sulphuretted hydrogen?

Witness: In removing the oxide you expose it to the air. I think I have explained that. In the one case the oxide absorbs the sulphuretted hydrogen, and deposits the sulphur in a solid form, and in the other the lime absorbs the carbonic acid, and the sulphuretted hydrogen is driven off into the air.

Mr. PAULI: With regard to the results of this very expensive and inconvenient mode of purification, what results have you obtained?

Witness: The results amount to something like this, that the sulphur compounds are diminished to little more than one-half. I have here the tests of the gas for sulphur compounds during 18 months—from July, 1870, to December, 1871—the first 18 months of the testing of the South Metropolitan gas, under the authority of the Referees. At that time no sulphur limit was fixed, and no lime whatever was used in the purification. There were during that time 415 tests made by the official tester, and the sulphur ranged from 25 to 42 grains in 100 feet; the average was 32 grains. The highest was 42·2, and the next highest was 40·5; it never exceeded 40 but on those two occasions. The lowest was 20, but I struck that out, as I believe there must have been an error. The next lowest was 24·9. You may say the range was from 25 to 42 when we used nothing but the oxide of iron, and the average was about 32 or 33.

Mr. PAULI: Do you consider that that reduction is at all compensated for by the trouble, cost, and nuisance involved?

Witness: I have hardly answered your question. The reduction is from an average of 35 to an average of a trifle under 20, and I certainly do not think it is worth the trouble and cost.

Mr. PAULI: Will you tell the committee the effect which the sulphuretted hydrogen or the sulphide of calcium has upon the men who enter the purifiers?

Witness: The effect upon the men is very objectionable. I have had men very often laid up for several days by temporary blindness. When the lime happens to be in a dusty condition it is exceedingly irri-

tating to the eyes, and nostrils, and throat. If it is in a very wet state, it clings to their hands and makes them sore; in fact, I very often feel exceedingly sorry to be obliged to require the poor fellows to work in those lime purifiers. I have tried respirators and gloves, which are of no use; the lime destroys the gloves. I got some of Professor Tyndall's respirators, those with cotton wool, and the men could not draw sufficient air through them when at work. I think it is the dust that affects the eyes.

Mr. PAULI: Do you find that in a gas-lighted room there is any practical difference between gas that contains 35 grains of sulphur and gas that contains only 15 grains?

Witness: In my own house I burn gas rather lavishly; and having had experience during all my life of burning different sorts of gas, I have never been able to detect the slightest difference, whether the gas contains 40 grains or 10; and I have burnt it under those conditions repeatedly. The unpleasant feeling which everybody more or less experiences from gas has never been traced to sulphur. I have read everything that has been stated upon the subject, and I have never seen or heard such an assertion. An ordinary gas-burner, burning at the nominal rate of 5 cubic feet an hour, would be equal to something like 15 or 16 candles. A small room would have three burners going; and multiplying that by 15, it would be perfectly absurd to put 45 candles in such a room. Probably the heat and unpleasantness would be something like it is from the gas, if the same quantity of light were required. The difference between gas and candles is this, that you are obliged to have gas at a distance from you, whereas you can bring candles close to you, which will serve equally well with a very much smaller quantity of light. I know something respecting the alleged effects of this sulphur on binding leather and furniture. It has been said that it destroys leather and furniture. I remember the case of the Athenæum Club. I do not believe that there is any truth whatever in the assertion that the bindings of books are destroyed by the sulphur compounds in the gas. I think there are other things which would account for it far more satisfactorily. I attribute it to the excessive heat chiefly. Evidence has been given over and over again to show that books and furniture will suffer just as much in a room which is hot, and where there is no gas burnt, as in a room where gas is burnt plentifully.

Mr. PAULI: I would ask you one more question, which does not affect us much; but I believe before you had imposed upon you this liability, you used to find your life generally much more pleasant than it is now?

Witness: A director's life is not an unpleasant one anyhow, but a manager's is very different. In my business as engineer, I used to take the extremest delight in it, and I have often thought that I could not have found a more pleasant and suitable occupation; but since there has been the trouble about the sulphur, it is perfectly unendurable. Sometimes I cannot sleep, and cannot think of anything else.

Mr. PAULI: With regard to the limits which are imposed in large towns in England, is it not the fact that the principal towns, such as Manchester, Birmingham, &c., have no limit whatever?

Witness: It is. I was at Manchester last year, and made special inquiry upon that point. I was there, called in by the corporation, in conjunction with Mr. Hawksley and Mr. King, to advise them as to the selection of plans for new gas-works to make 10 million feet a day. There were 28 sets of plans exhibited, and the corporation would not say anything about the sulphur. I therefore made further inquiry, and ascertained that they did not intend to take any trouble whatever about it, and did not deal with the sulphur compounds at all. In Paris I made a special visit of inspection two years ago, and ascertained precisely the same thing.

Mr. CRIPPS: It will probably be convenient to the committee if I state, before cross-examining the witness, the course that I intend to take. This is now a small part of a large case which is to come before the committee. In that large case I am also engaged, and we have the assistance of a great number of eminent persons, and my learned friend, Sir Edmund Beckett. I do not intend to interfere with that case in the slightest degree by what takes place in this case. It would be to give the committee a great deal of trouble to hear the same evidence twice over, and, therefore, I decline entirely, in this case, to go into any one of these scientific matters which

we must then have at greater length, and with better means of discussing them than we have in this case. I shall have just a few general questions to ask this witness, and I will dismiss all this science entirely for the present. Of course I do not assent, for the present purpose, to any portion of it.

Cross-examined by Mr. CRIPPS: The Crystal Palace District Gas Company were not included in the Act of 1860, which prescribed 20 grains as the maximum amount of sulphur impurity. Until the appointment of the Referees, all the Metropolitan Companies were under that Act, and, during all that time, it was not lawful to exceed that maximum. If they did exceed it, the manufacturers were liable to penalties; but it was not observed—that I can state most positively. In 1868 the legislation in this respect, in reference to the Chartered Company, was exchanged for what is now the Referee legislation. Subsequently this system was applied to nearly all the north of London. The legislation of 1868 altered the limitation of 20 grains of sulphur in 100 feet in the Metropolis, and enacted that the proper quantity should be determined by the Referees; but I think I am entitled to give the reason for that. It was found to be utterly impossible to comply with the 20 grains legislation. There was nothing known about it, so the committee thought, or the promoters and opponents of the Bill thought between them, that it would be fair to remit it to a scientific body. The larger question has to be fought before this committee with regard to the Referee legislation, and to their prescription of the quantity of the sulphur to be allowed. The experiments which I and others have ventured on are in their relation similar to those which affect the larger question, because if the larger company win their case it will relieve me at the South Metropolitan works. The Crystal Palace District Company are not a little company, except by comparison. About half the area they supply is within the metropolitan district. I represent that company here.

Mr. CRIPPS: Do you state for the South Metropolitan Company that you have not been able to comply, and have not complied, with this regulation about the 20 grains of sulphur?

Witness: I stated that I have not been able to do it continuously and perfectly.

Mr. CRIPPS: But you have been able to do it generally?

Witness: I perhaps have by creating a nuisance.

Mr. CRIPPS: I hold in my hand a report made by the Chief Gas Examiner on the results of testing the gas of different companies. It is a report made to the Metropolitan Board of Works, and I find for the last quarter, or rather the quarter ended on Dec. 31, 1876, the average result of the testing of your company was only 17·7 grains in 100 cubic feet.

Witness: Quite right.

Mr. CRIPPS: Then you have complied with the regulations?

Witness: Yes. I may go back a little, as you have referred to these reports, and state that in December, 1875, my gas was ten times over the limit of 25 grains—the Referees allow 25 grains in the Metropolis during the six winter months, and 20 grains during the six summer months. In the latter part of November, and during the month of December, I was 14 times in excess of the 25 grains; in the month of January I was ten times in excess, and I am bound to say here that the Metropolitan Board have always acted most fairly and liberally in these matters. However, from the end of January, 1876, up to the end of February of this year we went on without a single excess, and then the excesses came on, and why they came on I never could find out. We went up to 42 grains.

By the COMMITTEE: There is a larger margin allowed in the winter than in the summer because of the greatly increased quantity of gas that is made. We make four times as much gas in December in one day as we do in June, and therefore there is greater difficulty in dealing with it.

Mr. MICHAEL: The reason is that the larger make of gas taxes your purifying power?

Witness: Yes. People burn more gas in winter. We went on all right for 14 months, and then there was an excess of sulphur on the 1st, 2nd, 3rd, and 5th of March; and I think there must have been on other days, but the testing office was shut up for repairs. I wrote to Dr. Williamson,

the Chief Gas Examiner, and stated that there was something wrong, but I could not find out what it was; and here he quotes from me: "Though how or why, or to what extent, I am totally unable to say, unless the cold weather of last week had something to do with it." Then Dr. Williamson goes on: "A careful investigation of the circumstances of the case has brought to light evidence that portions of the lime in the purifiers have remained inactive, and I have reason to believe that the quality of the lime employed is subject to variations which affect its absorbent power."

Mr. CRIPPS: During the time that you have been under this restriction, and during the time that the metropolitan companies have been under this restriction, they have always claimed to divide 10 per cent.?

Witness: Yes, they have; but you know how it is.

Mr. CRIPPS: If the matter came to that, you could divide a little more in the South Metropolitan?

Witness: Yes; but you remember about the sliding scale.

Mr. CRIPPS: We will not go into all those matters now; but, however, you have managed to comply with the regulations and to divide 10 per cent., and could divide more?

Witness: Yes; our Act gave us the power to charge a price that would enable us to pay 10 per cent. That is altered now.

Mr. CRIPPS: Never mind what the Act gave you; your mode of making gas, as long as you are enabled legally to do it, does enable you to divide more than 10 per cent.?

Witness: Yes; it comes to this, that we make the consumer pay 2d. per 1000 for these things—perhaps 2d. per 1000 more than he would otherwise do. Why did not the Metropolitan Board insert the sulphur clause in their Bill when they proposed to have gas-works of their own?

Mr. PHILBRICK: Representing the consumers when they were bringing in a Bill to supply gas to London, I understand you that the Metropolitan Board of Works introduced their Bill without any limitation of this kind upon the purity of the gas?

Witness: They did; and every other corporation do the same.

The COMMITTEE: In what year was that?

Witness: That was 1875.

Mr. CRIPPS: That was merely a skeleton Bill introduced into Parliament.

Mr. MICHAEL: They wanted to reduce the companies to skeletons.

Re-examined by Mr. PHILBRICK: The Crystal Palace District Company supply a suburban district, and they have an absolute hard and fast limit of 20 grains in their Act; but in the Metropolis itself the companies which are under the Act of 1868 have no limit, but it is left to the discretion of the Referees. Originally the Referees fixed the sulphur limit at 30 grains, then it was reduced to 25 grains in winter and 20 in summer. We are therefore absolutely worse off in the suburban district than the great metropolitan companies are, because during the whole year we have the extreme limit put upon us which is put upon them in the summer time, when gas is easier to manufacture, and there is more time to purify it.

Mr. PHILBRICK: Now I do not want to go into other matters; but my learned friend, Mr. Cripps, asked you this: He said that the South Metropolitan could comply with the requirements of the Act, and yet divide 10 per cent. Are there circumstances connected with the history of your South Metropolitan Company which render you peculiarly situated with reference to your capital and to your dividend over every other company in the Metropolis?

Witness: Yes; and it simply comes to this, that we are allowed to charge a price for our gas which is sufficient to cover the cost of making it and to pay a 10 per cent. dividend, and it also covers the extra cost of lime purification. So that it becomes a question in this way, that if lime purification is more expensive, it is a matter which the unfortunate consumer has to pay for. The Crystal Palace District Gas Company are not a 10 per cent. company. They have £50,000 at 10 per cent., and the rest at 7 per cent. and 6 per cent. And although they have a maximum price of 6s., they keep the gas at 3s. 11d., and reduce it a penny when they can.

Mr. COURTNEY: Would the increased difficulty of testing this gas in winter, on account of the greater amount required, apply as much to the Crystal Palace Company as it does to any metropolitan company?

Witness: Yes, because their apparatus is in full proportion to their works, and there is a greater difficulty, especially in the depth of winter, because there is always a pressure on gas companies. We work at our full power.

Mr. COURTNEY: Is this process of purifying by hydrated peroxide of iron a very expensive one, as compared with purification by lime?

Witness: It was, when it was first introduced, just about as costly as lime, but the improvements that have been made have brought down the cost, so that, in some companies, they purify their gas really for nothing—it does not cost a halfpenny per 1000 feet. The value of the spent oxide is as much as the material in the first instance. You may buy fresh oxide at, perhaps, 50s. per ton, and when it is doubled in bulk you sell it at 25s. per ton.

Mr. COURTNEY: The process with the hydrated peroxide is not at all open to the disadvantages of disagreeable smell and injury?

Witness: The only objection that has ever been urged to the oxide of iron process is, that it does not attack the sulphur compounds other than the sulphuretted hydrogen. On all other grounds it is undoubtedly and undeniably the best.

Mr. COURTNEY: Besides the injury to the eyes and hands of the men by the actual contact of solid lime in the process of purifying by lime, do you think that the vapour given out, which produces the disagreeable smell, is injurious to human beings—to health?

Witness: I have been amongst it all my life, and I cannot say that the smell is injurious. The workmen are mostly engaged in the air in these processes. There is free circulation of air; so that I do not think their health is injuriously affected by the emanations, only by that contact with the solid lime.

Mr. COURTNEY: The Crystal Palace Company are under the same limitations as the metropolitan companies were under before 1868?

Witness: Precisely. The limitation was imposed in respect of this company in 1873. It was made in the case of the metropolitan companies because the Act of 1860 was totally inoperative; and it was utterly impossible for the committee to settle what should be the proper limit, therefore it was remitted to the Referees to investigate.

Mr. COURTNEY: You do not think it necessary to have any limit?

Witness: By the use of oxide of iron the quantity of sulphur in the gas will not exceed these 40 grains, and, therefore, I think the limit is unnecessary; but if any limit is imposed, we should probably have to use a portion of lime, and that would not be a small portion, because the whole of the carbonic acid having to be removed first, we should have nearly as large a use of lime if we were limited to 35 grains as if we were limited to 25. Moreover, if you use lime you get sometimes less excesses; for instance, the Crystal Palace Company, on one occasion, when they used lime, had 49 grains, and they were prosecuted by the Lewisham Local Board for it. That was entirely owing to the carbonic acid in the gas driving off some of the sulphur compounds that had been absorbed by this lime, and sending them on with the gas. The lime absorbs them, but it holds them with a very feeble affinity; and if I passed a stream of carbonic acid into this bottle, you would have those sulphur compounds driven off largely.

Mr. *George Wilson Stevenson*, examined by Mr. MICHAEL.

I am a gas engineer, carrying on business in Westminster, and have had large experience in gas undertakings. For the past ten years I have been consulted by the Corporation of London and the Metropolitan Board of Works upon all questions affecting the supply of gas in the Metropolis. I know the works of the promoters, and the district supplied by them, and the Acts under which they are authorized to supply gas. I have read the Bill which is now under the consideration of the committee. I know pretty well section 17 of the Act of 1873, which the Bill seeks to repeal. I gave evidence upon the Bill in 1873. At that time very little was known

with certainty as to the cost and inconvenience attending the purification of gas from sulphur compounds other than sulphuretted hydrogen. Since 1873 there has been a very large amount of inquiry, and a very considerably augmented knowledge as to these sulphur compounds. Nothing even now is exactly known as to the conditions in which they exist in gas, or a precise and scientific determination of the quantity. From time to time the same gas, tested in exactly the same mode, will give different results. The best means of taking out the sulphur compounds, I believe, are not yet known. I gave evidence as engineer in favour of the Bill of 1873, and was cross-examined by Mr. Philbrick, who then represented the Metropolitan Board of Works, on the general question of impurities in gas. In re-examination I stated that I thought 20 grains might be inserted, and upon that, without any question, it not having been asked at all of me in cross-examination, the promoters of the Bill at once assented to put in 20 grains as the limit. There was no discussion about the 20 grains; it was merely because I at that time stated from my knowledge up to that time that 20 grains might safely be inserted. If I had had the knowledge I have at the present time, I should not have stated that 20 grains was a safe limit to put in. I could not have done so. There has been no department of gas manufacture which has been submitted to more critical inquiry the last few years than the purification of gas, and we have knowledge now in regard to the cost, inconvenience, and nuisance occasioned by the elimination of sulphur compounds that we had not a few years ago; and with my present knowledge I could not say that 20 grains of sulphur, other than sulphuretted hydrogen, is the proper limit to impose upon a gas company. At the present time there are no other means known which can be used practically for taking out the sulphur compounds, other than sulphuretted hydrogen, except the use of lime, and that, too, in its most foul state—in a state of sulphide of calcium. That being so, in my opinion it was almost inevitable that a nuisance, and a nuisance of a very considerable extent, must be created by such a mode of purification. The lime is used in a very foul state—it is made foul in large quantities—it has to be removed from the purifiers by manual labour; and then, unless a river carriage is available, as it is at some stations, where they can put it into barges immediately, and cover it with tarpauling, or with some deodorent, the foul lime has to be put into carts or railway vans, and everybody who comes near it, or into whose neighbourhood it is brought, complains of the nuisance. It is a deleterious matter to deal with on the part of the workmen who are engaged in the process; it injures their hands and their sight, and produces nausea.

Mr. MICHAEL: Previously to the introduction of hydrated oxide of iron as a means of purification, lime was the purifying agent employed, I think?

Witness: Yes; I can remember when milk of lime was employed, and it resulted in what was called "Blue Billy;" and a very valuable mode of purification it was, except for the nuisance it created. It was on account of that nuisance that chemists so ardently sought for some other means of purification to avoid the use of lime. It was on that account also that oxide of iron was hailed as a great boon, as it entirely superseded the use of lime as a means of purification from sulphuretted hydrogen. No sulphuretted hydrogen is under any circumstances permitted in gas. It is an injurious compound, and is strictly prohibited and most carefully guarded against in every well-conducted works. There is no proposition in the present Bill that any sulphuretted hydrogen should be allowed. The Gas-Works Clauses Act, 1871, which is the general legislation on the subject, prescribes an entire freedom from sulphuretted hydrogen, and except for a special provision in a special Act, the general legislation does not provide for the removal of any other sulphur compound than that. The Board of Trade have passed, I think, some seventy Provisional Orders since 1871, which have been confirmed by Parliament, for the regulation of gas companies in the provinces, and in not one of those is there any other restriction with regard to sulphur than the complete elimination of sulphuretted hydrogen. The last of these was in 1876.

Mr. MICHAEL: You are very well acquainted with the Acts which have been passed for transferring undertakings from companies to corpora-

companies to corporations, I have never seen any clause dealing with the question of purity. In the Bill to enable the Metropolitan Board of Works and the Corporation of London to supply gas, there was no such clause, and I did not advise one.

Mr. O'HARA: Was not the reason of that, that where this interdiction comes into the hands of the local authorities they are the representatives of the people, and the people can put the screw on them if they do not give the gas which they ought to do?

Witness: That is very plausible, but it is utterly impossible for the consumers to know whether they are burning gas with 5 grains of sulphur or 50. I will defy any consumer to tell whether he has 5 grains or 50 in his gas; 50 grains in 100 feet of gas will not corrode silver, or leather either.

Mr. O'HARA: At all events, as a fact, these matters are left by the ratepayers and burgesses of towns to the local authorities?

Witness: They are, and the fact is that when gas-works or water-works are in the hands of the local authorities there is very little complaint.

Mr. O'HARA: Supposing that the local authorities were to make default in following any prescribed regulation, and that default was accompanied with a penalty. Who would pay the penalty?

Witness: The ratepayers.

Mr. O'HARA: Then would it not be absurd in the ratepayers to be paying penalties out of their own money?

Witness: You may say so.

Mr. O'HARA: But is not that the reason? You know perfectly well, no one better; and no one can be more candid. Is not that one of the reasons why these clauses are not put into corporation Bills?

Witness: You are assuming that the ratepayers and the consumers are identical. They are not so; or, if they are as regards numbers, they are not as regards the degree. There is a good deal of fallacy in those arguments. I do not agree with you; I do not think they are identical.

Cross-examination continued: I suppose it is possible to disinfect the foul lime; it is a question of expense and space, and the possibility of subsequent nuisance. I think that gas cannot be purified by lime without producing a nuisance. The purifiers at Fulham are not small; I think they are amply large enough. If they were much larger the smell from them would not be considerably less. I remember the passing of the Act of 1860, but I was not concerned in it. That Act prescribed 20 grains of sulphur. By the Act of 1868 the limit was left to the Referees, because it was found that the limit prescribed in 1860 could not be kept within, and it is not now kept within by the companies still under that Act. I know what the maximum prescribed by the Referees is. It is 30 grains in winter and 20 in summer. I do not know that it is 15 in some places. For the Commercial Gas Company no limit has yet been fixed, because their new works have not been finished.

Mr. O'HARA: The Referees, in their printed Instructions, say, "For gas made at the works of the Commercial Gas Company it shall be 30 grains."

Witness: I have not seen that; it must be just out.

Cross-examination continued: I do not know as a fact what the average impurity at those works has been during the last six or eight months. I should not be at all surprised to hear that it has been kept down to 17·7 grains. There are times when it may be kept down to 10 or 11, but that is not the point at all. I do not mean to suggest for a moment that 20 or a less number of grains may not be attained. I was a witness for the Crystal Palace District Company in 1873. Since that time I have acquired a great deal of information that I did not possess before, with regard to purification by lime and its cost, the space required for it, and the nuisance occasioned by the spent lime. It has not come suddenly upon me, but by degrees, as most information does. At Oporto my works were not far from the river, and I could very easily get rid of the lime, but gas was more costly to purify in that way, and I used oxide. The gas in Paris is not made from the same coal as in London; I think it is mostly Belgian coal. I should think that coal is as likely to produce foul gas, but I really do not know. I only know they do not use lime. In the three provincial cases I mentioned, in which 30 grains of

sulphur impurity had been fixed of late years, I should have said the companies volunteered that limit; it was not put upon them. In the Crystal Palace District Company's case, I believe they volunteered 20 grains. I gave evidence at the time, which perhaps conduced to their getting their Act in that form. All the information I now give in reference to the matter has come since 1873. I dare say I should be prepared now to qualify a great deal of evidence I then gave as to purification.

Mr. O'HARA: Do you think it advisable that a company should be left entirely free as to sulphur impurities?

Witness: As to sulphur compounds, yes; as to sulphur impurities, no. Of course, they ought to be restrained from sending out gas with sulphuretted hydrogen in it, but as to sulphur compounds I think they may be safely left perfectly free.

Mr. O'HARA: What would be the amount of sulphur that might, in that way, get into and pollute the atmosphere?

Witness: I do not know about polluting the atmosphere. The quantity of sulphur in other forms than sulphuretted hydrogen would be about 35 grains. It might go up to 40 or more, but not to 50 grains. If you put it at 40 I think that would be the extent.

Mr. O'HARA: Do you not think you can put it up to 50 without any very great effort?

Witness: I will leave that for somebody else to do.

Re-examined by Mr. MICHAEL: Under exceptional circumstances the quantity might be largely increased. I do not mean to suggest for a moment that it is not possible by the use of lime to bring down the sulphur to even something less than the average which has been mentioned; but in order to do that there must be a far greater nuisance than the presence of the sulphur itself. Practically it does not make any difference whether the purifiers are small or large. If they are small they have to be frequently changed, and if they are large they last longer unchanged, so that there is a larger bulk of this foul stuff taken out at once. The oftener you carry off the nuisance the smaller the amount. There is no known means of preventing the nuisance altogether.

Mr. MICHAEL: Is not that contemplated in the very clause of the section which provides that the Referees are to take into account the difficulty of putting an absolute test to the amount of sulphur without occasioning a nuisance to the neighbourhood in which the works are situated?

Witness: Yes, only this company are not under that provision. I do not think that the presence of 40 or 45 grains of sulphur in 100 feet of gas would be injurious to a person burning gas in his own room, but that can be better spoken to by chemists. As far as I have studied the question as an engineer, there is no case in which that amount of sulphur has caused injury, either to person or property.

The CHAIRMAN: You said that the limit of 20 grains of sulphur compounds allowed by the Act of 1860 had practically to be given up, because it was found to be impossible to obviate it.

Witness: It could not practically be acted upon. There are several companies now in London that are still under that Act—the Phœnix and the Surrey Consumers on the south side of the Thames, and the London on the north side of the Thames—and they are not proceeded against.

The CHAIRMAN: I want you to explain this, because you did not quite finish one of your answers. You were asked, "Might it not be the fact that, in some companies, the average of these sulphur compounds was kept down to 13 grains?" and you said, "Yes; that might be so, but that is not the question." I want to know what it was you meant to say?

Witness: I was asked that question in regard to the works of The Gaslight and Coke Company at Beckton, Bow, and Bromley, where they can use any quantity of lime without creating a nuisance to the surrounding neighbourhood.

Mr. O'HARA: You were asked that question by me, in reference to all the gas companies in London except the South Metropolitan.

Mr. MICHAEL: You read, as I understand, to the witness, the average amount of impurity from sulphur compounds during three months period, which amounted to 13·7 grains. Was not that so?

Witness: I understood so.

Mr. O'HARA: What I had in my mind at the time was this: I excluded the South Metropolitan, and I took all the others. The Gaslight and Coke Company, for example—at all their stations.

Mr. MICHAEL: It is but fair to read this table. The Gaslight and Coke Company's average is 12·6; at Ladbroke Grove, 14·1; Millbank Street, 19—that is cannel gas; Carlyle Square, 14·1; Camden Street, 14·7, &c. My friend has added these together, and takes his figures, I suppose excluding the 19, at 13·7—that is to say, over the whole of that period the proportion of sulphur in other forms than sulphuretted hydrogen, taking the average, amounts to 13·7. Then I asked the witness whether, under exactly the same circumstances, it might not suddenly rise to 25, or even 35, when employing that means of purification?

Witness: It should be explained that fully two-thirds, if not three-fourths, of the gas supplied by that company is made at Beckton, Bow, and Bromley, where they can use an unlimited quantity of lime without creating any nuisance to the neighbourhood; therefore, it is to be expected that we get a very low average of sulphur impurities in the gas supplied from those stations; but from the stations and districts where it is not admissible to use a large quantity of lime it will be found that the sulphur impurities are very much larger, and what I meant by "that is not to the point" was this, that while it was quite possible, by the abundant use of lime, to bring down sulphur impurities to a standard like 13·7, or even less, the means of doing that would create a far greater nuisance than the nuisance they do get rid of by the elimination of a difference of between 13 and say 35 grains of sulphur from the gas.

The CHAIRMAN: Then do I understand that the reason why it is found practically impossible to maintain the limit of 20 grains, required by the statute of 1860, is on account of the nuisance?

Witness: Yes; and the impossibility of getting space in which to manipulate the gas through lime.

The CHAIRMAN: Have you, yourself, heard of any complaint from the Crystal Palace district of the nuisance of the lime at the works?

Witness: I have not. I do not live in that neighbourhood, but I believe evidence will be given to that effect.

The CHAIRMAN: Then, besides the injury to the hands and eyes of the men who clear out these lime purifiers, do you consider there is any injury done besides to the health or life of human beings?

Witness: I am not aware that they permanently suffer from it, but they have to be paid extra wages, and they have to be coaxed to their work. It certainly does lead men into drinking habits; they will drink, and drink to excess, over this work. To outsiders, who are not employed in it, there is really no nuisance except the smell.

The CHAIRMAN: As to the metropolitan companies, you are aware of the existence of the restriction, between 1860 and 1868, of 20 grains, the same as in the Act of this company, and you know that there was substituted for it, in 1868, the Referees jurisdiction?

Witness: Yes.

The CHAIRMAN: You knew it in 1873, when you gave evidence?

Witness: I did; but I thought that out in the country, as these people were, they might be able to use that quantity of lime without creating a nuisance; but the district has got so overbuilt that it is a very great nuisance. In fact, that point was put to me; I am free to say, that the question of the 20 grains was not in my proof for the promoters. It was put to me in an off-hand way, and I said, "I think you may safely put it in at 20 grains." I was aware of the practice of the metropolitan companies before that.

TUESDAY, MAY 1.

Mr. *Henry Palfrey Stephenson*, examined by Mr. PAULI.

I am a member of the Institution of Civil Engineers, and deputy-chairman of the Crystal Palace District Gas Company. I have been a director of that company since their origin, about 23 years ago. We have come here after mature consideration, and, as we consider, in the interest of the

public. Previously to 1873, we were under no obligations to purify from sulphur compounds, the only restriction in our Act of 1858 being with regard to sulphuretted hydrogen. We were specially exempted from the restrictions contained in the Metropolis Gas Act of 1860, after opposition on our part. Excepting for the 17th clause of the Act of 1873, we should have no restriction imposed upon us with regard to sulphur compounds other than sulphuretted hydrogen.

Mr. PAULI: When you heard that limit imposed, you had no idea of the difficulty, or expense, or nuisance that would be involved in carrying out the duty?

Witness: I consulted with another engineer who was in the room, and, looking to the fact that we had made a considerable increase in the area of our purifying power of late years, and not at all anticipating the difficulty which would arise from the waste lime and the foul lime, we were under the impression that we should have no great difficulty in purifying from the sulphur compounds, according to the limit then mentioned. We were anxious to obtain our Bill, and, therefore, we did not raise any objection to the clause, anticipating that we should have no difficulty. Before 1873 we used lime to absorb both carbonic acid and sulphuretted hydrogen. We were not then alive to the necessity of taking the carbonic acid from the gas before the sulphuretted hydrogen. We used a very small quantity of lime in proportion to what we are now using. As soon as we tried to carry out the provisions of that section, we found that our limits as to those sulphur compounds were frequently exceeded, and that it was necessary largely to increase the area of our purifiers, and also the quantity of lime used, and that involved a considerably increased expense. About the year 1867, I think, the area of purifying power was rather over 1000 cubic feet, 16 feet deep; by the year 1873 we had increased it to over 3530 square feet, 6 feet deep; and we have since 1873 increased that by about 50 per cent., or 1750 feet. The sulphur compounds sometimes increased in such a manner that we could not account for them, unless possibly it arose from the waste lime itself giving up some sulphur compounds to the gas instead of taking them from the gas. We now use a process which may be described as two very large lime purifiers, and four oxide purifiers, working the lime purifiers separately—the first one to take out the carbonic acid—and, in the second one, the sulphuretted hydrogen, being driven forwards, forms an artificial sulphide of calcium, which has been found by Mr. Patterson—or was pointed out by Mr. Patterson—to be the material which ought to be used for purifying the gas from sulphur compounds other than sulphuretted hydrogen. After the second purifier the gas passes into the oxide of iron purifiers, of which we have four. We have some lime in the bottom trays of the oxide purifiers, as a sort of safety-valve or guard against any other sulphur compounds passing the sulphide of calcium purifiers. After that long and complicated process, we generally keep the amount under 20 grains, but at first we had considerable difficulty in doing so. With regard to the refuse lime, it becomes very foul and exceedingly offensive. We first used to bury it in the works; but for fear of fouling the stream which is in the neighbourhood, and in consequence of complaints and a memorial from the inhabitants, we found it necessary to give that process up. We then carted it away to an old brickfield, about a mile distant from the works, but after a storm some of the refuse was washed into the river Pool, and so into the Ravensbourne, and it made a great nuisance, causing great complaints. We also had complaints from the inhabitants of the district through which the stuff was carted, and since then we have arranged to send it away by railway trucks, at a cost of about 5s. per ton, which entails upon us for that alone from £200 to £250 per year. We send it away in railway trucks especially kept for the purpose, and bought by our company, because the railway company objected to their waggons being used for the foul stuff. We brought a siding up alongside the purifiers, so as to load the trucks direct when we empty the purifiers, so as to avoid causing a nuisance. I have a plan here showing the purifying works, as we had them in 1873, and as we have them now. Before 1873, this being our retort-house [pointing to the plan], the gas was conducted from the retorts along a pipe, called a

horizontal condenser, and in travelling along that pipe it travels with the tar and ammoniacal liquor and gas all mixed together. Here it is freed from naphthaline and tar and ammoniacal liquor, and all the liquid elements, and then it travels along this pipe to what we call the battery condenser, and at this point the liquor there is admitted, and the tar proceeds into the tar-well. Then the gas passes through this battery condenser, which is a huge box with horizontal pipes through it, and it is there cooled down to about 65° at this point. Passing from that it comes into the two scrubbers, which are round vessels made of cast iron, filled with breeze, or with boards, or with broken bricks, about 24 feet high. It is washed in those scrubbers by ammoniacal liquor travelling through the brickbats as the gas proceeds upwards. It is then taken along this pipe to the exhauster, which is for the purpose of pumping the gas through the different apparatus. It then goes into the washer, which is filled with water, and then commences the purification. Before 1873 we had those two smaller lime purifiers of 20 feet by 22 feet; the gas passing through these deposited some of the carbonic acid and sulphuretted hydrogen, we not distinguishing, at that time, whether it was carbonic acid or sulphuretted hydrogen that was taken out of the gas. Then it proceeded to the four oxide purifiers, which took out the sulphuretted hydrogen. In this case, which is since 1873, the purification by the horizontal condenser and the other condensers is the same. We pass now, however, through the washer first, instead of through the scrubber, and then we pass through two scrubbers, in one of which we scrub with ammoniacal liquor, and in the second with very weak ammoniacal liquor; then we pass either to those two purifiers or to this purifier [pointing to the same]. Supposing these two to be used, we use that one to take out the carbonic acid, and that enables the sulphuretted hydrogen to flow into this one, where the sulphide of calcium is formed, which then becomes the purifying agent for the sulphur compounds. When this one is changed, to remove the lime filled with carbonic acid and partly with the sulphuretted hydrogen, then we use these two. As soon as that is changed and refilled with pure lime, then we shut off those two, and proceed to use these two, and those four are, as before, the oxide purifiers, with the exception that we have a bottom tray, or large square boxes with lids upon them, which have a bottom tray filled with lime as a sort of extra safeguard against any sulphur compounds coming over when we are using those two purifiers. There is a difference of area of about 50 per cent. Those two large purifiers are 50 per cent. of the area of these purifiers.

By the COMMITTEE: If we obtain this Bill, we shall use all these oxide purifiers, and, of course, it will save us the erection of some oxide purifiers in the future. If we do not obtain our Bill, I think it exceedingly likely that we shall be compelled to erect large purifiers in place of those two. If we obtain our Bill, we shall only use a very small portion of lime, principally in the trays.

By Mr. CRIPPS: There is nothing exceptional in the form of the purifiers, but there is a little exception in the mode of using them; we work them according to a plan pointed out by Mr. Patterson some few years ago, about which there has been a Chancery suit in two courts.

Mr. CRIPPS: In which you were fortunate enough to succeed.

Examination resumed: The lime, when thoroughly saturated with sulphuretted hydrogen, becomes sulphide of calcium. I have no doubt the effluvium which is smelt arises from the sulphuretted hydrogen, which is very deleterious. I should not like to live in an atmosphere of that kind. We have had, from time to time, a great number of complaints, in particular one in 1875 from 20 inhabitants of the district surrounding the works.

Mr. PAULI read the memorial, which was as follows:—

To the Chairman and Directors of the Crystal Palace District Gas-Works.

Gentlemen,—We, the undersigned inhabitants and householders of Lower Sydenham and Perry Hill, desire to call your attention to the great and increasing nuisance caused by the stench arising from your works, which we believe can at a small expense to your company be considerably mitigated, if not entirely abated. We are given to understand, and believe it to be the fact, that the smell complained of is partially caused by the increased quantity of lime used in purifying, but there is no reason why this should be

allowed to become a nuisance; as it should be carted away in closed receptacles, a system adopted by the metropolitan works. The noxious fumes arising from your works have become so intolerable, that they will considerably depreciate the value of house property in the neighbourhood, for several inhabitants of the district have been so often awakened in the night, almost suffocated with them, that unless your engineer adopts measures to prevent a repetition of them, they will be compelled to leave their houses. We appeal to you, as gentlemen connected with a wealthy company, to extend us your sympathy, and to give such instructions to your officers as will afford us relief.

The CHAIRMAN: I gather that that was rather a protest against the practice of storing lime than against the use of it.

Mr. PAULI: It was a protest against the increased use of the lime. They say, certainly, that it would be decreased if it could be carted away in closed vessels.

Examination resumed: However we deal with the lime, we shall always have a considerable amount of offensive smell, particularly at the time of changing the purifiers, or in damp and foggy weather, with the wind in certain directions. Sulphuretted hydrogen is given off the moment the purifiers are opened, and particularly when the foul lime is stirred up. By the time it is put into the vans the smell would have escaped. I understood from Mr. Stevenson's evidence yesterday that at some of the works they take considerable care in sending it away, and yet there is a large amount of smell and nuisance. I do not personally know how the metropolitan companies get rid of their foul lime. Many of them have water carriage, and yet find great difficulty with their lime. I do not think they inquire where it goes to if they get rid of it.

By the COMMITTEE: It is said that it is pitched into the water at the mouth of the river, but I do not know whether that is so or not.

Examination resumed: I have made a very accurate calculation showing the increased cost arising from the extra use of lime which has been imposed upon us. I have taken 3½ years before the passing of our Act of 1873, and 3½ years since the passing of that Act. The cost before the passing of the Act was 0·318 of a penny, and since 0·875 of a penny. But during 1876 we had still further to increase the quantity of lime, and the cost was 1·166 of a penny. The net result to the consumer, taking into consideration the interest, and so on, is a cost of 1d. per 1000 feet, and that would represent about £1500 a year upon the amount sold. During the 3½ years before the passing of the Act, we used 807 cubic yards of lime; but during 1876 we used 1576 cubic yards in that one year, which almost amounts to one bushel per ton of coal carbonized.

By the COMMITTEE: During the whole 3½ years, after the passing of the Act of 1873, we used 4449 cubic yards. The increase in the quantity of gas did not make an increase in the quantity of lime, but for the purpose of taking out the sulphur compounds we increased the quantity of lime so as to do so more effectually. During the first 3½ years we carbonized 93,720 tons of coal, and during the next 3½ years we carbonized 125,865 tons, but the quantity of gas made does not affect the cost of purification per 1000 feet of gas. During the first 3½ years we used 0·180 bushel of lime per ton of coal carbonized; during the second 3½ years we used 0·742 bushel; but during the last year we used 0·832 bushel, or four times as much as the average of the 3½ years.

Examination resumed: Having regard to the suburban character of our district, it may be assumed that the consumption will increase from year to year, and that therefore more lime will have to be used. We have had nominal penalties imposed on two occasions. We find that if we try to reduce the quantity of lime, then we run the risk of penalties under the Act; but if we increase the quantity of lime, then we run the risk of complaints from the neighbours, and there is a local press, so we get it hot both ways. We have understood that our company have been considered an exemplary one. We have a maximum charge of 6s., but we only charge 3s. 11d. to the general public, and 3s. 7d. to large consumers and the public lamps. In 1873 our illuminating power was raised from 10 to 14 candles, but we did not object to that. In our Act a certain number of hours notice is required previous to testing, but we have waived that with the parish officers. I have never heard of any approximate advantage which has been derived from reducing the sulphur compounds from a little below 30 to, say, 20 grains. I think we should still have to use a con-

siderable quantity of lime with a limit of 30 grains—enough to create a nuisance. I think the great fault among consumers is, that their rooms are not sufficiently ventilated, and very often bad burners are supplied to them; in consequence, a great deal of imperfect combustion takes place.

Cross-examined by Mr. CRIPPS: There was a very strong attempt made to bring us under the Act of 1860, but it was not successful, because we were exempted from the provisions of the measure. When we applied for our Act, in 1873, we asked Parliament for power to raise £150,000 at 7 per cent., but that capital is not yet issued. When it is issued it will only be with a certain amount paid on it, so that we could not take the premiums that the fully paid-up stock of the London companies would take. I should think, if we issue those shares with £2 paid, they will take a premium of from 25s. to 30s., or, perhaps, £2, in the market. The ordinary premium of 7 per cent. stock is about 50 per cent., and that amount will be divided amongst our shareholders as a bonus when it is called up. It must be remembered that when we obtained our original Act we had power to raise £100,000 at 10 per cent., but we only took £50,000 at 10 per cent., and the other £50,000 at 7 per cent., thereby denuding ourselves of £2000 a year.

Mr. CRIPPS: I am not talking about your old Act, but about the Act in which this particular disadvantage, as you term it, was imposed upon you. You did get that £50,000, which, when you want to issue it ultimately among your shareholders, would be worth to them 50 per cent. premium?

The CHAIRMAN: I am not sure I follow the drift of your cross-examination. You do not propose to set off any advantage gained by the shareholders, under this Act of 1873, against the nuisance they would be to the public, do you?

Mr. CRIPPS: I intend to set it off most materially against anything like a complaint of its causing any extra expense in gas-making.

Witness: I do not complain of the cost.

Mr. CRIPPS: It will cost rather more than you have paid at the present time to get rid of that difficulty; but I am now particularly upon the Act which gave you that undoubted benefit on which you first accepted this liability. The population of your district within the metropolitan area is, of course, the part which has been increasing most materially since 1860, and since this prohibition was first introduced?

Witness: I would not say that, because the whole district has been increasing. It is not within my knowledge that the clause complained of was proposed with a number of other clauses by the Metropolitan Board of Works, some of which were put in and some not. My belief is that it came out in the examination or cross-examination of Mr. G. W. Stevenson, and we accepted it under the belief that we could comply with it. The effect of that clause was to impose upon us the same prohibition which had been put upon all the other metropolitan gas companies. The great reason we bring this Bill forward is the nuisance that it commits to our neighbours. The trucks in which the lime is sent away are not closed, but open. The greatest amount of nuisance occurs when the purifiers are opened and the stuff is being thrown into the trucks. On a large scale, there is no way of purifying that lime before it comes out of the purifiers. As a chemical process, if you put a small portion of waste lime into a retort and burn it, I dare say you will throw off all the noxious vapours from it. I very much doubt if it could be done by simply admitting the atmosphere, but I would rather not give an opinion on a chemical point like that. I have heard there were one or two explosions caused by that method being adopted. Whatever of that kind was to be done would, of course, be an increased expense for us.

The CHAIRMAN: With reference to this suggestion of purifying lime by airing it, at what stage of the process is that attempted?

Witness: I have not used it myself.

Cross-examination resumed: When I spoke of being summoned on two occasions, I referred to being summoned, under the Act, for having an excess of sulphur compounds, other than sulphuretted hydrogen in the gas. I do not think we were summoned on the question of nuisance. The Lewisham Board wrote to us complaining very much of the foul water from the brickfield flowing into their stream, but I do not recollect that we were sum-

moned upon that question. The extra penny of expense involved in this matter has not been any detriment of our dividend, because it is paid by the consumer.

Mr. CRIPPS: You mean you would be able to reduce the price to the consumer if you made your gas cheaper?

Witness: I believe so.

Mr. CRIPPS: Do you know whether the consumer is particularly anxious to have this amount of sulphur compounds poured into his room in order to get his gas cheaper?

Witness: I think the consumer is under a misapprehension that he is poisoned by sulphur.

Mr. CRIPPS: Have you had any applications from the consumers to state that they would be willing to take this increased quantity of sulphur as against paying a little less?

Witness: No.

Mr. CRIPPS: You have mentioned the largely increased quantity of lime you had consumed in your works since you undertook this liability, but does not that involve a decrease of the quantity of oxide used?

Witness: I should think not. We sell the spent oxide at a profit, so that we should not object even if we required a little more. We have removed our lime by means of the railway trucks for about seven or eight months, but that was not the plan which was adopted at the time the memorial was addressed to us.

Re-examined by Mr. MICHAEL: The only way in which this expense affects us is that we are, as it were, handicapped as against the surrounding companies. At Croydon they are not under any restriction as to sulphur compounds, and therefore we are obliged to charge 1d. more for our gas than they are, If we were relieved from an obligation of this kind it is the consumers who would be benefited. No process has ever been brought to our notice by which we could discharge the sulphur from the gas without creating a nuisance. If it had, we should have adopted it, unless it was at an enormous expense.

By the COMMITTEE: The large purifier takes one day to empty out, and one day to refill, with 20 men, so that it may be said there are 36 hours during which the stuff is exposed. The actual process takes about 24 hours, but there is the time during which it is waiting in the train to be taken away. During the winter time we change our lime purifiers once in every 12 days. If the purifiers are changed on a day when the wind is blowing directly away from the houses, there would be no complaint on such a day as that; but, in the depth of winter, with the wind blowing in the direction of the houses and villas on the height above our works, then, of course, the smell is noticeable on those days.

Dr. *William Odling*, examined by Mr. MICHAEL.

I am a Fellow of the Royal Society, and a Professor of Chemistry in the University of Oxford. For the last 20 years I have devoted very considerable attention to the question of gas purification and manufacture, and was one of the Gas Referees during the years 1873 and 1874. When gas is produced it contains gas in a form which may be described as sulphuretted hydrogen, and also as sulphide of carbon; it is not, chemically speaking, the latter, but that is the description generally. Sulphuretted hydrogen is a gas with an exceedingly offensive smell, and it exists to a very considerable extent in crude gas—I believe about 400 or 500 grains in 100 cubic feet, and the retention of that amount would be a very objectionable thing. It is very easily recognized by a test paper, if any is left in the gas. The gas ought to be supplied to the consumers absolutely free from sulphuretted hydrogen, and is so in that supplied by the London companies. A piece of bibulous paper is saturated in a solution of acetate of lead, and is kept constantly suspended over the gas in all good gas-works, so as to enable the engineer in charge at once to detect if any sulphuretted hydrogen exists in the gas, and records are kept of that test. In addition to the sulphuretted hydrogen, there is a proportion of sulphur existing in the gas which has not the property of affecting test-paper. In this residuary sulphur, which is generally spoken of as "sulphur other than sulphuretted hydrogen," there exists undoubtedly sulphur in the form of

sulphide of carbon. In the Crystal Palace Gas Act of 1873, a maximum of 20 grains of sulphur compounds was allowed to remain in the gas, but it was to be perfectly free from sulphuretted hydrogen. There had been restrictions in the Metropolitan Gas Acts for years, but up to 1872 or 1873 there were no means known for reducing the sulphur other than the sulphuretted hydrogen to any extent at all. There is now only one process, so far as I know practically, and that consists in the use of lime in the manner described by Mr. Livesey and Mr. Stevenson, although a great many proposals have been made. I am aware that an experiment has been tried of introducing into the purifier atmospheric air, in order to see whether that would not to a great extent remove the nuisance complained of when the purifiers were opened, but I have not seen the operation. It would be difficult to say what is the extreme power of lime in reducing the quantity of sulphur other than sulphuretted hydrogen in gas, but I believe, in a practical operation, it will reduce the amount to about half. I think it is a matter of scarcely any importance whether there are 15 or 30 grains in 100 cubic feet. One hundred cubic feet of gas would weigh from 3 to 4 lbs.; therefore, if you have 30 or 40 grains of sulphur in 3 or 4 lbs., that would be about 10 grains in the pound; and if you halved that it would be reduced to about 5 grains in the pound, or if it is put as a per centage, the amount of impurity, which originally is one-seventh per cent, would be reduced to one-fifteenth per cent., and that is practically a matter of no consequence whether the gas is burnt in the open air or in rooms. In conjunction with Dr. Russell, I have instituted a series of experiments, in which gas has been burnt with a known quantity of sulphur, our aim being to have all the conditions which ordinarily exist. The room employed for the purpose was one of the offices of the South Metropolitan Gas Company, and the experiments have been going on for three or four months. The room was 18 feet 10 inches in length, 17 feet broad, and 12 feet high, and that would give a capacity of about 3800 feet. It had two windows and a door, and was furnished as an ordinary sitting-room, lighted by means of a chandelier, hung from the centre of the ceiling, having three lights fitted with Sugg's bat's-wing burners, at a height of 7 feet from the floor, and each of them burnt with great regularity 5 cubic feet an hour; they were also provided with governors and tested by meters. There was a moderate fire maintained in a grate to keep up the ordinary conditions, and the door was continually kept shut; but people came in and out as they pleased, and there were one or two persons usually in the room. The gas which we burned was some which had been prepared without having been purified with lime. It was tested 23 times, as I am informed by the official tester, who found it to contain, as the mean of his 23 observations, 33 grains of sulphur in 100 cubic feet. We lighted the gas some hours before beginning our experiments, and we ascertained, by a considerable number of experiments, that if the gas had been lighted for four or five hours the atmosphere of the room underwent no further alterations, either in chemical composition or temperature; but after four or five hours we got it up to the maximum of heat and impurity, and beyond that the continuous burning had no further effect. In commencing the experiment, measured quantities of air were sucked through aqueous ammonia, to absorb the sulphurous products, and we satisfied ourselves, by preliminary experiments, that in this way were absorbed the whole of the sulphurous products that were in the air — in fact, we used a very much greater amount, practically, of absorbing power than was necessary—and then were estimated the amount of sulphurous products. I also took the atmosphere after the gas had been kept burning continuously for 20 hours, and in some cases 48 hours, but there was no sensible variation. We took the air first of all from a height of 1 foot 6 inches from the ceiling; we had previously ascertained that the products of gas combustion aggregated very largely in the upper part of the room. Then we also took it at the height of about 5 feet 6 inches from the floor, which represents about a man's ordinary breathing height; and we took it at a height of 3 feet 6 inches from the floor, as representing a man's ordinary breathing height sitting down. At 1 foot 6 inches from the ceiling, the mean of three experiments, gave us 16 grains of

sulphur in 10,000 cubic feet of air, or ·160 in 100 cubic feet. At 5 feet 6 inches we found the result rather less than at 3 feet 6 inches, but that arose from the fact that the latter series of experiments was a mean of three, whereas the 5 feet 6 inch series was a mean of two, by reason of an accident, one portion being thrown away. Those experiments were compared with that of a room in which the gas had been burnt for two hours, and in that case, whereas formerly we had 16 grains in 10,000 feet, we had now only 10 grains, but with reference to the 5 feet 6 inches and the 3 feet 6 inches there was no substantial difference. We also took the air of a room in which gas had not been burnt at all, and in place of the 10 grains we found there was only between one-tenth and two-tenths of a grain. A minute quantity of sulphur is invariably found in the air, from the combustion of coal which is going on. The quantity of sulphur compounds found in the air would certainly not have any appreciable effect upon health or life; it only amounts to about one part in the third of a million up at the ceiling, and one part in about three-quarters of a million at the breathing height. There is no doubt that in rooms that are heated by gas, the hangings, books, and furniture, in the upper part of the rooms, do suffer very considerable deterioration, and it has been alleged that that is due to the sulphurous particles of the gas; but that, I say, is not the fact, for two reasons—first, other conditions are amply sufficient to account for it, and secondly, the sulphur itself is not capable of doing that amount of injury. The following are the results obtained by myself and Dr. Russell:—

Grains of sulphur per 100 cubic feet of air, found in the air of a room of 3800 cubic feet capacity, in which gas containing 33 grains of sulphur per 100 cubic feet had been burnt at the rate of 15 cubic feet of gas per hour for upwards of five hours continually.

	I.	II.	III.	Means.
At height of 1 foot 6 inches from ceiling .	0·184	0·123	0·173	0·160
At height of 5 feet 6 inches from floor. .	0·056	0·037	—	0·046
At height of 3 feet 6 inches from floor. .	0·058	0·032	0·088	0·059

Gas Burnt for Two Hours only.

	I.	II.	III.	Means.
At height of 1 foot 6 inches from ceiling .	—	0·135	0·076	0·106
At height of 5 feet 6 inches from floor. .	0·049	0·070	0·045	0·052
At height of 3 feet 6 inches from floor. .	0·039	0·050	0·037	0·042

Not any Gas being Burnt.

	I.	Mean.
At height of 1 foot 6 inches from ceiling	0·020	0·020
At height of 5 feet 6 inches from floor	0·010	0·010
At height of 3 feet 6 inches from floor	0·009	0·009

We find the air in the upper part of a room is prejudicial, in the first place, from its high temperature. After the gas has been burning in a room for four or five hours, we find that the temperature in the upper part, 12 feet high, would increase by some 20°, whereas the temperature of the breathing height will only increase some 5° in the course of a few hours. In using the three Sugg's burners, the illuminating power was about 50 candles. There is no doubt, when gas is burnt, that the products of combustion and heated air have a much greater tendency to concentrate themselves in the upper part of a room when the light is aggregated together than when the same amount of light is obtained from a number of small jets, as is the case with candles. The oppressiveness which people experience in rooms lighted with gas depends not only on the high temperature directly, but also upon the high temperature indirectly; because, having an accumulation of heated air at the upper part of the room, that part of the room is virtually cut off for the purposes of respiration. In the room in which we are now assembled, the hot breaths ascend into the air above; but if the room were cut off at the height of the door, we should find the room much more oppressive. If instead of the room being cut off at the door, it was filled with hot air, or so hot that it could not mingle with the lower stratum, the room would be virtually cut off at that height. By the combustion of gas there is a certain amount of water formed, and, therefore, the absolute amount of water in the air is in-

creased relatively to the amount of water that the air is capable of taking up. It is decreased—that is to say, the air is less saturated with water after the gas has been burnt in it than it was before. This is shown by the fact that the wet bulb of the thermometer indicated a difference of 10° —there was that difference between the wet and dry bulbs of the thermometer near the ceiling, and only a difference of 5°, 6°, or 7° below. That showed that the upper part of the room was not only hot but dry, and that would have a great influence upon books, pictures, and various articles exposed to its influence. We also examined the gas with regard to the other impurities produced by combustion. The amount of carbonic acid existing in the open air may be taken at 4 volumes in 10,000 volumes. In the room in which we experimented, this proportion rose to upwards of 40 volumes near the ceiling, above the chandelier, and to 20 volumes below; that is to say, it increased ten times near the ceiling, and five times at about the respiration level. It is generally considered that the presence of a large amount of carbon in the atmosphere in any form is prejudicial to health and life. The volume of carbonic acid gas furnished by the carbon of gas coal may be taken as at least a thousand times greater than the volume of the sulphurous products produced by the burning of sulphur. Carbonic acid has no smell; and everybody knows that on going into a gas-lighted room there is a certain amount of smell and chokiness which is not due to carbonic acid at all, but it has long been attributed to the products of imperfect combustion. If gas is burnt in a room where the amount of air and gas are not exactly regulated, either the gas is under-burnt or over-burnt, and in either case strong-smelling offensive products are formed. We have taken some trouble—I believe for the first time—to get some idea of the proportion of these products, and they are, I may say roughly, that where the amount of carbonic acid in the air of the room has been so far increased as to amount to from 1½ to 3 grains in a cubic foot, we find those other impurities resulting from the imperfect combustion of gas—which give rise to that choking sensation—amount to from half a grain to a grain in a cubic foot in addition. The difference between 20 grains and 40 grains of sulphur would not alter the carbon compounds in any degree whatever. If a room is properly ventilated, a small proportion of sulphur does no harm in any way; but if it is not properly ventilated, the removal of it will do no practical good, by reason of the large amount of carbon products. We know that so much sulphur is capable, when it is burnt in a certain way, of yielding so much sulphuric acid, and it may be taken that the amount of sulphur contained in the gas which would be burned in an ordinary room in the course of a week, is an amount which would be capable of yielding enough sulphuric acid to destroy all the furniture; but the fact that the furniture does not get destroyed in a week, a month, or a year, shows that that amount of sulphuric acid is not the point at issue, which is to determine the amount of sulphuric acid, if any existed, in the room in which gas was being burned; all other modes of determination have no bearing upon the question. I am quite of the opinion that the removal of the restriction which exists will not enure to the disadvantage of the public. With regard to the alleged injurious effects of this small proportion of sulphur, it is not the result of observation, but it is the result of a notion that it must produce sulphuric acid when it is burnt, and that sulphuric acid, when it is burnt, is a very dangerous thing. I say that the evidence that this is not the case, is shown by the fact that sulphur is very largely used for bleaching silk and woollen goods, and also for the purpose of disinfection—not merely sulphur as sulphur, but sulphides of carbon. It is common to burn a quarter of a pound of sulphur per 1000 cubic feet of space, so that in the very room in which we were experimenting, they would burn about a pound of sulphur, and burn it till the air became so opaque, it could not be seen through. The room would be closed for a couple of hours at least, and then the windows would be opened, and the room ventilated, and the furniture would be found not to have suffered any inconvenience; and that would show that any injury experienced by rooms in which gas was burned was not due to the exceedingly minute proportion of sulphur contained in the gas. Taking the maximum quantity of

sulphur which we find in the room in which we now are, a person would have to go on breathing for six or eight hours in order to take into his lungs, in the course of respiration, as much as the twentieth of a grain of sulphur, from which no bad result would follow. Supposing no other process than oxide of iron were used, so far as sulphur is concerned, I am not prepared to say what would be the maximum quantity of sulphur left in the gas, but on an average it would amount to about 30 grains, or a little over. No other purifying material than oxide of iron is used in Manchester, Birmingham, or Liverpool, nor yet Paris, and that has been adopted after considerable inquiry as to whether or not other means should be adopted.

Mr. MICHAEL: We have it from Mr. Livesey's own observation; but the general question I wish you to satisfy the committee upon is this: Supposing oxide of iron to be used as a means of purification, under any circumstances, do you know whether there would be any prejudicial amount of sulphur other than sulphuretted hydrogen in the gas?

Witness: No; and I base that partly upon all these observations and experiments, and partly on the fact that it is not found to be prejudicial in such towns as Paris, Liverpool, and Birmingham.

Cross-examined by Mr. CRIPPS: My experiments have all been made for the Crystal Palace District Gas Company.

Mr. CRIPPS: Your experiments go to filling the room once with gas, and then trying the results; but you would hardly compare that with the case of a room where gas was burnt continually every day and every night for years and years?

Witness: Of course every day would add to the injury. My experiments were made in a room 12 feet high, but taking London, the rooms in artisans dwellings are generally very much lower than that. I think there is a distinct difference between the air which is above the chandelier, if there be one, and that which is below. There is no absolute impossibility to supply gas with less than 20 grains of impurity in 100 feet, but it is entirely a question of expense—to use a common expression, whether it is "worth while."

Mr. CRIPPS: Do you really suppose that the public of London, who know that they have been protected for years past from impurities, will be satisfied when they find the alteration has been made?

Witness: I should say there is not the slightest proof as to the presence of sulphuric acid.

Mr. CRIPPS: But the sulphurous acid may become sulphuric acid by the addition of another element, oxygen?

Witness: With so much sulphur, if you please you may make so much sulphuric acid; the only question is whether it exists in a room lighted by gas.

Mr. CRIPPS: But what they are breathing and what they are having enter their rooms may be ultimately sulphuric acid?

Witness: No; I dispute that.

By the COMMITTEE: Sulphurous acid would become sulphuric acid by the admixture of oxygen. There is abundance of oxygen to supply it; the point is whether the amount of sulphur that is found in the room actually gets converted into sulphuric acid or not. I say the thing is quite conceivable, but the question of whether it does or not can only be tried by experiment.

The COMMITTEE: You mentioned the burning of a pound of sulphur; how long a period of continuous gas-burning would that represent?

Witness: A pound of sulphur would be 7000 grains. It would require about 20,000 feet of gas to yield that amount of sulphur, and at the rate of 15 feet per hour would have to burn for over 1200 hours. I only made that statement as an illustration that there might be a very great amount of sulphur in a room, and that that sulphur was a product which did not damage the fabrics.

Re-examined by Mr. MICHAEL: Those experiments were conducted over a period of three months. A person standing in a low room would suffer more from the defilement of that room by gas products; but this defilement is not attributable to the sulphur compounds, but the carbonic compounds.

Mr. MICHAEL: Therefore, as far as sulphur is concerned, it being nothing,

if you multiply nothing by any amount it remains nothing still, but when you take the other defilement from merely burning the gas—the carbon compounds and the other matters producing defilement of the atmosphere —of course, the less the amount of that dilution the greater the injury produced?

Witness: Yes. As regards the general result of my own observations I should say that of the very small proportion of sulphurous products which are produced, about one-tenth part of that small proportion is converted into a state of sulphuric acid, and that is in a large measure neutralized by the ammonia existing in the air, and would become sulphate of ammonia, and this being a neutral salt, no injury would occur from that small quantity being present. If anything like the amount of sulphur that was in the gas was converted, by burning, into sulphuric acid—if more than a mere trace was so converted—it would not be a question like the present before the committee, because it would be found that the furniture would be destroyed. It would practically result in this—that no gas could be burnt in a room which was not thoroughly ventilated, whereas we know that gas is burnt in rooms in which there is a total absence of ventilation.

By the COMMITTEE: I have not tabulated the results as to carbonic acid, but I can state them generally. Near the ceiling we got 40 parts in 10,000, and at the breathing height 20 parts in 10,000.

The COMMITTEE: Would these particles of carbonic acid, however formed, not produce any smell or disagreeable influence upon the nostrils or lips?

Witness: Actually carbonic acid itself does not, but these other products of imperfectly burnt gas, and these other carbonaceous products, do.

Dr. *William James Russell*, examined by Mr. PAULI.

I am a Fellow of the Royal Society, and Professor of Chemistry at St. Bartholomew's Hospital. I have been generally engaged with Dr. Odling in making these experiments, to which he has spoken. I have also heard his evidence, and agree with him in all respects. I believe that the unpleasant effect in rooms does arise from those carbon compounds, and that sulphur has nothing to do with it. We did not appreciate the presence of sulphur, although it would be very easily traceable.

Mr. PAULI: You would have found out, by your experiments, whether there had been carbonic acid or not?

Witness: No, we should not, as far as our experiments went; they would apply more to those sulphurous compounds, or sulphuric acid. The means we took to collect it would have collected it whether it was sulphurous acid or sulphuric acid. Any quantity of either of those acids would exercise a very prejudicial effect upon the leather of bookbinding, and so on. I have heard that great damage has been attributed to the sulphur compounds in gas, in libraries and other places, but I do not believe it is owing to those compounds.

Mr. PAULI: Do you believe it would be any practical benefit to the public at all that the sulphur compounds in gas should be reduced, we will say to 20 grains in 100 cubic feet?

Witness: I do not think they would be able to tell the difference in the least.

Mr. PAULI: Do you agree with Dr. Odling in the infinitesimal amount of these sulphur compounds which you would have to breathe?

Witness: Yes. I think our experiments really show that one would have breathed the tenth of a grain of sulphurous acid into the system, assuming that the whole of the sulphurous acid that went into the system remained there, which would not be the case. With reference to those experiments, our principal object was to get a room which should be as similar as possible to an ordinary room in London. I confirm the evidence of Dr. Odling with regard to the general results of those experiments.

Cross-examined by Mr. CRIPPS: I do not know that there is any reason why proper ventilation should never be ensured in the dwellings of the lower classes; there is no practical difficulty about it. The same thing might be said with regard to the dwellings of the higher orders.

Re-examined by Mr. MICHAEL: Sulphuric acid in a concentrated form is a very corrosive substance, and if it were brought out in that corrosive

form in the ordinary process of burning gas, we should find in every room traces of its presence. All the goods would be spotted over with it, and holes formed in them. The carbon compounds ought certainly to be got rid of by ventilation, but that is beside the mark when we are discussing the presence of sulphur as an injury.

Mr. MICHAEL: If the ordinary process is adopted of purification with oxide of iron, would there be left such a quantity of sulphur in the gas as would lead to injurious results when that gas was burnt?

Witness: I think not.

Mr. MICHAEL: Therefore it is useless to resort to the process of purification by lime?

The CHAIRMAN: I think Dr. Russell says he agrees entirely with the last witness.

Mr. CRIPPS: They would not think of burning gas in any quantity in the wards of St. Bartholomew's Hospital, would they?

Witness: I should think so.

Mr. CRIPPS: Are they not very particular to have one burner in a ward and the window open?

Witness: I really do not know what the arrangements of the hospital are, but I hope they adopt what you suggest—good ventilation.

Mr. MICHAEL: Supposing they do, has that any reference to the quantity of sulphur in the gas?

Witness: I should say not. The object of ventilation is to get rid of the products of combustion in the heated air.

The COMMITTEE: Can you give any idea what is really the difference between sulphuric and sulphurous acids, in regard to their deleterious effects, if any?

Witness: Sulphuric acid is the stronger of the two, and would turn out sulphurous acid, while sulphurous acid would not turn out sulphuric acid.

Dr. *Thomas Stevenson*, examined by Mr. MICHAEL.

I am an official gas examiner, and also a Professor of Chemistry at Guy's Hospital. I have heard the evidence of Dr. Odling and Dr. Russell, and concur in that evidence. I believe I first introduced the use of bisulphide of carbon as a disinfectant, and I have used it exclusively for the disinfecting of rooms in the portion of the Metropolis in which I have been Medical Officer of Health for the last six years. I have used, not pounds, but half a ton in that time. Bisulphide of carbon is a compound of carbon and sulphur, made by passing sulphur over heated charcoal. It exists in the form of a transparent liquid, which is highly volatile and inflammable. When using it as a disinfectant, it is simply placed in an open dish in quantities varying, according to the size of the room, from about one-fourth of a pound to half a pound at a time; a match is then applied, and the vapours and the liquid are allowed to burn. A small quantity comparatively of carbonic acid is produced, and a very large amount of sulphurous acid, so that in a few moments no one can stay in the room so as to breathe. The room is then shut up, and left in that way for several hours, and then the doors and windows are thrown open, and the room can then be occupied; this is done after infectious disease. That sulphurous acid is in contact with the oxygen of the atmosphere.

Mr. MICHAEL: Is it under precisely the same circumstances as the sulphurous acid which may be formed from the combustion of the gas with the sulphur compounds in it?

Witness: Yes; the only difference is that it is in a larger quantity in the room when you burn bisulphide of carbon. I have made experiments with the sulphur in gas, and I find that on burning the gas only about 5 per cent. of the sulphur in the gas, as determined by the Referees apparatus, is directly converted during combustion into sulphuric acid, and that most of that sulphuric acid is neutralized by the ammonia present in the gas and in the atmosphere. During the six or seven years I have employed bisulphide of carbon, we have had only one claim for compensation for destruction of any article in the room, and that was bleaching an artificial flower and a bonnet, the sulphurous acid being a bleacher. I have had no claim for compensation of any kind for the corrosion of articles.

Mr. MICHAEL: This unfortunate artificial flower, if sulphuric acid had been formed, I take it, would have been destroyed by the corrosive action of the fluid upon it?

Witness: I think it would, and I also think we must have had a large amount of destruction prevailing everywhere, in furniture and so on, if any appreciable amount of sulphurous acid had been converted into sulphuric acid.

Mr. MICHAEL: Of course there was a very much larger quantity of sulphurous acid formed than there possibly could be created by burning gas with any amount of sulphur?

Witness: Yes. I should like to add that there is one condition which would determine the conversion of sulphurous acid into sulphuric acid, which is absent in rooms, and that is the presence of an excess of ammonia in liquid, which is an essential condition for the rapid conversion of sulphurous acid into sulphuric acid. That is not present under ordinary circumstances in burning gas. There is an inappreciable amount present of ammonia.

Mr. MICHAEL: Have you ever seen any bad results from the combustion of gas containing sulphur which could be traced to sulphur compounds?

Witness: None which could not be traced to other conditions developed during the burning of the gas, those conditions being increased temperature, increased dryness of the atmosphere, and increased products of combustion, carbonic acid, and so on. I have a table here, which will confirm Dr. Odling:—

DR. THOS. STEVENSON'S EXPERIMENTS ON HYGROMETRY, &c., IN ROOMS IN WHICH GAS IS BURNT.

1. *Drawing-Room.*—11 feet 3 inches high. Capacity 3000 cubic feet. Occupied by two adults. Fire. Three bat's-wing burners, each consuming 4 cubic feet of gas per hour. Gas burnt for 4¼ hours before testings were made.

	18 In. above Floor.	4 Ft. above Floor.	1 Ft. below Ceiling.
Temperatures	61°	63½°	79½°
Relative saturation of air with moisture; total saturation = 100	69	55	46
Volumes of carbonic acid in 10,000 volumes of air	—	7·70	44·2
Grains of water required to saturate 1 cubic foot of air with moisture	1·53	3·10	5·87

2. *Dining-Room.*—11 feet 3 inches high. Capacity 3500 cubic feet. Occupied by two adults. Fire. Three bat's-wing burners, each consuming 5 cubic feet of gas per hour. Gas burnt for 4¼ hours before the testings were made.

	3 Ft. above Floor.	7 Ft. 9 In. above Floor.	1½ Ft. below Ceiling.
Temperatures	61°	68°	77°
Relative saturation	60·5	58	44
		8½ Ft. above Floor.	
Volumes of carbonic acid in 10,000 vols. of air	18·6	35·0	
Grains of water required to saturate 1 cubic foot of air with moisture	2·36	3·15	5·59

3. The last (dining) room, lighted with three good oil lamps on table. No gas.

	5 Ft. above Floor.	7 Ft. 9 In. above Floor.	1½ Ft. below Ceiling.
Temperatures	66¾°	64°	68°
Relative saturation	61	54·5	45
Grains of water required to saturate 1 cubic foot of air with moisture	2·87	3·59	4·57

PROPORTION OF SULPHURIC ACID TO TOTAL SULPHUR OBTAINED BY BURNING COAL GAS FROM A BUNSEN BURNER.

1. *The Gaslight and Coke Company's Gas.*

Total Sulphur in 100 Cub. Ft. of Gas.	Sulphur as Sulphuric Acid from 100 Cub. Ft. of Gas.
14·66	0·97
19·07	1·09
19·45	0·74
16·32	0·91
16·07	0·84
Averages 17·11	**0·91 or 5·32 per cent. of total sulphur.**

2. *Surrey Consumers Company's Gas.*

Total Sulphur in 100 Cub. Ft. of Gas.		Sulphur as Sulphuric Acid from 100 Cub. Ft. of Gas.
23·00	..	3·81
38·35	..	1·44
38·86	..	1·82
39·24	..	0·27
55·38	..	1·44
Averages 38·97	..	1·90 or 4·87 per cent. of total sulphur.

QUANTITIES OF COMBINED AND FREE SULPHURIC ACID CONDENSED ON GLASS PLATES AND ON CALICO AFTER 24 HOURS EXPOSURE IN GAS-LIGHTED ROOMS.

1. *Plates Clean and Dry.*

Sulphur in Gas used in Grains per 100 Cub. Ft. of Gas.		Size of Room in Cub. Ft.		Quantity of Gas Burnt per Hour.		Total Sulphuric Acid, Free and Combined, Deposited on 1 Square Foot of Surface, in 24 Hours.	
19·07	..	2016	..	10	..	·020	
35·75	..	3840	..	15	..	·003	
36·02	..	3840	..	15	..	·006	
33·70	..	3840	..	15	..	·006	
39·60	..	3840	..	15	..	·016	
						·010	average.

2. *Plates Moistened with an Alkali (Carbonate of Sodium).*

19·07	..	2016	..	10	..	·068	
36·02	..	3840	..	15	..	·055	
39·60	..	3840	..	15	..	·042	
23·65	..	3840	..	15	..	·039	
36·83	..	3840	..	15	..	·252	
—	..	3840	..	15	..	·214	
—	..	3840	..	15	..	·201	
						·124	average.

3. *Clean Calico (Six Days Exposure).*

34·00	..	3840	..	15	..	·380	
34·00	..	3840	..	15	..	·290	
						·330	average.

It thus appears that only 8 per cent. of the sulphur in the air is deposited on plates not covered with an alkali—*i.e.*, in their natural condition.

The quantity of *free* or *corrosive* sulphuric acid deposited was too small to admit of accurate determination.

I find the same conditions are not present when I light the room with lamps as with gas, because so much absolute amount of light is not required when lamps are used. When you use gas you burn it in a chandelier in the centre of the room, but when you use lamps or candles you place them near where they are wanted on the table. There is also another thing—viz., that gaslights are usually clustered together, and form a strong ascending current of highly heated and light air, which ascends to the top of the room, and there remains practically fixed at the level of about the doorway, or a little above, so that the whole atmosphere about six inches above the down outlets is practically a heated, dry, and foul atmosphere, cut off from ventilation from the upper part of the room, and very destructive, no doubt, to all articles—books, and so on—which are exposed on the upper shelves of a library. Such an amount of carbon compounds in the atmosphere as I have mentioned would be injurious to health, and would show that ventilation was required, not on account of the sulphur products, but on account of the carbon matter. I have determined also the amount of condensation of those different products, and I find it was very small indeed.

By the COMMITTEE: I have exposed glass plates, and also clean washed calico in various parts of the room where gas has been constantly burnt—one of the rooms being the same as that used by Dr. Odling—and I find that the amount of sulphur deposited on those objects is exceedingly small. The total amount of sulphuric acid deposited was, on an average,

per square foot of glass, after 24 hours exposure, only 100th of a grain, and that was nearly entirely in the non-corrosive form of sulphates. As Medical Officer of Health, I complained of the nuisance created in the King's Cross district by the use of lime. I called upon the company to abate the nuisance, and I went thoroughly into it, being at that time advising Mr. Patterson as to his patents.

Mr. MICHAEL: Did you not institute some experiments as to the ventilation of the lime purifiers in order to get rid of the nuisance?

Witness: I called upon the secretary of the then Imperial Gas Company. The company carried out some experiments in the ventilation of the purifiers. I did not see them carried out, but I saw the result of passing air through them, and they were most disastrous. They made a far worse nuisance, and damaged the purifiers.

Cross-examined by Mr. CRIPPS: Those experiments were carried out at the Bromley works, but they did a great deal of mischief, and had to be modified; there was an injunction against them. I am not personally acquainted with the Beckton works. There has been a general tendency to remove gas-works from among the populations to places where it was supposed the nuisance would not do much harm, but there are still some remaining in the central parts of London.

Mr. CRIPPS: You have stated that where gas has been burnt there is something deleterious, which you think can be accounted for by its being dry, hot air?

Witness: Dry, hot, foul air, but not foul from sulphur.

Mr. CRIPPS: There must be some compound arising from gas manufacture besides the mere heat and dryness, in order to produce the effects which you state.

Witness: Not from gas manufacture, but from gas combustion. I think the sulphurous acid is so small that it is quite inappreciable—something like one part to 1000 parts of the carbon products. That sulphurous acid is capable of becoming, by the intermixture of oxygen, sulphuric acid, but that is a very slow process, unless you have an alkali present.

Mr. CRIPPS: However slow it may be, it does ultimately become sulphuric acid?

Witness: If it is not removed; but it does not remain for a sufficient length of time in the upper part of the room to become an appreciable amount of sulphuric acid. If it did remain there, and there was no further ventilation, it would become sulphuric acid after a very long exposure—perhaps weeks.

Mr. CRIPPS: After the gas had gone on burning for weeks and months together?

Witness: Yes; but then you have at the top of the room an atmosphere which practically, after four or five hours, becomes uniform, and then we may take it that as much new products of the combustion of the gas are thrown in as old ones removed. Practically the amount of foulness is not going on accumulating, but represents an uncertain quantity.

Re-examined by Mr. MICHAEL: Gas is ordinarily burnt for a certain number of hours, and then for a much greater number of hours it is not burnt. I find from experiments that, in the course of a few hours—say five or six, or even less—if the room is well ventilated, it resumes its ordinary condition in which it was before the gas was burnt. I have found that in a small ill-ventilated room, on turning out the gas and leaving the door ajar, and going in the morning and testing the atmosphere again, it was practically the same as the day before, previous to the gas being lighted.

The COMMITTEE: Are we to understand that when the air at the top of the room is charged with a certain amount of this sulphurous compound, whatever it is, that it does not become any more charged, no matter how long the gas may be burning? Does the air give it off, or does it sink down to the floor; or what happens?

Witness: No doubt a small portion escapes by the ordinary channels of ventilation, if there are any in the upper stratum, and part of it passes into the lower stratum of the atmosphere; and just as much of the foul products in the upper stratum of air as passes down into the lower stratum will pass upwards from the products of combustion.

The COMMITTEE: Do you mean to say that the air is not capable of

carrying or of containing at that rate more than a certain charge of those compounds?

Witness: No, I do not exactly mean that; but as the particles of combustion pass to the upper stratum of the atmosphere, they must turn out some of the old stuff that was there; and that just as much as is turned out or displaced in the upper stratum is raised from the lower stratum. It is just like a cistern tap with water running in—as much water must run over the top of the cistern as runs in from the tap. At the works near King's Cross, being in a populous part, they are allowed 5 grains more sulphur per 100 cubic feet than they are allowed at Bromley, and I believe the object of that is to keep down the nuisance.

Mr. *James Layton*, examined by Mr. PAULI.

I am a bookbinder, residing in Brewer Street, Golden Square. I have devoted a great deal of attention to finding out the best mode of preserving the binding of books. In 1843 there was an inquiry at the Athenæum Club with respect to the bad state in which the bindings of their books had got, and I was called upon to investigate the circumstances. The result was that I found there was absolutely no difference in the condition of the books in a room in which gas was burnt, and the condition of similar books in rooms in which no gas was burnt at all. After paying a great deal of attention to the matter, I came to the conclusion that the state of the books was attributable to the extreme temperature at the top of the room. In the north library there was no gas burnt, and the state of the bindings in that room were even worse than in some of the others in which gas was burnt. The temperature of that room was very high, owing to the flues of the kitchen, and the obvious conclusion was that those books went bad entirely from the excessive heat. I am also binder to the Royal Institution. Gas is there burnt continually in the reading-room, but there are very few books there. In the library they have gas occasionally—the secretary tells me about 19 nights in the year, not more—but the books there are in a very bad condition, the upper part particularly. They are quite as bad as in libraries where gas is burnt continuously. Witness handed in a specimen of the state of the binding of many of the books from the library of the Royal Institution; another one from the library at the Travellers Club, where there is no gas burnt at any time. I was acquainted with the Duke of Norfolk's library in 1863. There were two rooms—one the library below, and a room in which books were kept next the roof. There was a very great difference in the temperature of those two rooms. In the summer time, with the sun shining on the roof, the top room was very hot. The books in the lower library were in a very good condition generally, and suffered very little, but those in the top room were very dry and perished, and on removing them the binding would often break off. There was no gas in either of the libraries.

Mr. PAULI: Then I suppose the general conclusion you came to was that the burning of gas in a room has no practical bearing upon the condition of the books, but that the condition of the books was due entirely to the temperature?

Witness: No further than this, that gas, I think, is a great source of heat; I find it hotter where gas is burnt.

Mr. PAULI: But the decay in the books you attribute to the immense temperature? You have shown pretty conclusively that the presence or absence of gas has nothing to do with it?

Witness: It is the dry atmosphere, I think.

By the COMMITTEE: The temperature at the Travellers Club is generally very high, they being gentlemen who have seen a great deal in the East, and they like the warmth.

Mr. CRIPPS said he should not cross-examine the witness in the present case.

Mr. MICHAEL said he would not trouble the committee with any further evidence.

Mr. CRIPPS said he should have very few remarks to make in the present case. It would be obvious to the committee that the question of the Crystal Palace Gas Company was no more to the Metropolitan Board of Works than the question of any other particular district within their

jurisdiction. It so happened that a small portion of the Crystal Palace district was within the jurisdiction of the Board, and it also happened that the Bill next to be brought before them affected nearly the whole portion of the district under their jurisdiction. The question, so far as they were concerned, was to protect generally the interests of the gas consumers throughout the Metropolis, and it was quite obvious that the proper course for the Metropolitan Board to take was as follows:—There were parties applying for a privilege which the Metropolitan Board and the consumers believed would be detrimental to them, and, on behalf of the Board, it was desirable to hear all the evidence given in favour of that charge. It was a very heavy onus which the companies were taking upon themselves. It might be that they would be able to prove the case they had undertaken; but as there would be a large body of evidence, scientific and otherwise, to be given in opposition, he (Mr. Cripps) asked, on behalf of the Metropolitan Board, that the decision on the present case might be reserved until all the evidence on the general case had been given. It was true that the counsel would not be the same in both cases, but there were representatives, and they would be perfectly able to represent the whole case when it came before the committee. The question of the gas supply of the Metropolis had been a matter of agitation between the gas companies and the consumers for a considerable number of years. Unfortunately, they had not felt their interests always to be identical, although they really were so, and would ultimately turn out to be so. There was no one a gas director looked upon with more suspicion than a gas consumer, except it was the Metropolitan Board of Works, who, as representing the consumers, were looked upon as worse than the consumers themselves. The consequence had been that, for some years past, a considerable contest had been going on, commencing from 1860 to the present time. A number of Acts of Parliament had been passed, conferring powers on one side or the other, all of which had been more or less compromises of the views of the two parties. In 1860, which was the inception of the matter, and the first Act in which the limitation of 20 grains of sulphur in 100 feet appeared, the gas companies rather than the Metropolitan Board originated the agitation which led to that Act. The companies obtained a very great advantage in that year, which should not be underrated on their part, which was that the Metropolis was divided into different districts, and a supply was given to a particular company, and appropriated entirely to that company, so long as they were able to supply the district, and so long as an inquiry before the Home Office, or something of that kind, did not alter it. Of course there were certain restrictions placed upon the companies, amongst which was the restriction that their gas should be free from sulphur compounds to a greater quantity than 20 grains in 100 feet. The Crystal Palace District Gas Company were not at that time sufficiently within the Metropolis to make that Act applicable, and they were exempted from its operations. In the meantime, the district, like all other districts round London, became more and more metropolitan. Ultimately, in 1873, the Crystal Palace District Gas Company applied for power to raise £150,000 at 7 per cent., which capital, under the Gas-Works Clauses Act, was to be offered in the first instance to the holders of the old shares. In return for that great benefit, the company had to submit to the likening of their district to what was common in other parts of the Metropolis with respect to the sulphur impurities, and they were limited to the 20 grains per 100 feet. That was the contract entered into with the consumers, and it was upon that the consumers rested their case. They said, "We allowed you to have certain benefits upon your incurring certain restrictions for our benefit. We made a great point of our desire to have the gas purer than it was before. You submitted to that, and you have gone on now for a certain number of years supplying gas of that purity, subject to penalties if you do not supply it, and you take a very heavy onus upon yourselves in coming to alter the bargain which you entered into with us at the time."

Mr. COURTNEY: You do not present it in that way. Your petition says it was a mutual bargain which had been paid for.

Mr. CRIPPS said one did not want to put everything in a petition. He was entitled to rely upon the whole case.

Mr. COURTNEY: You are here only to raise it upon the question of health—upon a sanitary question.

Mr. CRIPPS said that was a point he was coming to, but he was then viewing it generally, and therefore was entitled to take any objection. The undertaking the company gave had been carried out from that time till the present, but now they asked to be relieved from that responsibility, on the ground that it was impracticable to do it. They did not say, "We cannot give the gas pure," but all they said was, "It is an expense, and is inconvenient to us," and made them very unhappy; but were those real reasons? If it was any real injury to the company it could be proved, but they continued to divide their maximum dividends. They alleged it was an injury to the consumers, because if they could make their gas cheaper they could supply it cheaper, and every extra penny they paid for the extra purity fell on the consumers. Be it so. The consumers did not ask to be relieved from it. They preferred pure gas, and paid for it, and did not desire any alteration. Then they said, "Oh, but it compels us to make a nuisance at our works;" but that was very indefinitely proved. It was very true that at the present time where the Crystal Palace works were was much more surrounded with houses than places where gas was generally manufactured in the Metropolis, but what did that amount to? Of course, if a nuisance was created at those works the company could be indicted for that nuisance the same as anybody else could be. But what was the evidence of that nuisance? There was a small memorial, signed by about a dozen persons, which was presented about two years ago with reference to what was being done at those works, and all that the memorial suggested was that the company should adopt some other way of taking away the impurities in a closed conveyance rather than in the way they were doing. What did the chairman say? He said, "We took it away in carts for some time, but now there is a great improvement. The trucks of the company come to the gas manufactory and take away the products direct; but we do not attempt to cover over the trucks." Surely, if the matter were so urgent, they could, at no very great expense, have some trucks made specially for that purpose. Of course, they ought to be so constructed as to be covered, and so prevent any nuisance; but even as it was, since they had adopted that plan there did not appear to have been any complaints at all—certainly none had been proved. The committee had simply the statement that it would be less expensive to the company if they had not to use that method. Under those circumstances, was there anything proved as a reason why the bargain of 1873 should be reversed? They had heard a great deal of evidence that it did no harm to have the 20 grains of sulphur, but surely the consumers were judges of that; it was purely a consumers question. It was not for the gas company to say, if the consumers desired to have that impurity, "You are mistaken, and are taking an unreasonable view." They might try to persuade a person that there was no harm in the gas he was breathing from time to time; but if he felt that there was, and if he did not desire to have any impurity introduced from which he was free, surely that was for the consumer. Mr. Livesey had told them it could be done, and also that during the very last quarter the amount had only been 17 grains in 100 feet. There was no difficulty in the matter; it could be done, and had been done, and the inhabitants of the Metropolis had had the benefit of it; and now, because of some doubtful evidence (for what could be more doubtful than those laboratory experiments about sulphuric acid?) was the whole Metropolis to be told they were to have gas more impure for the future, because they were asked to remove that restriction of 20 grains, whether the proposition in the present Bill was to be 30, or 40, or anything else?

The CHAIRMAN: Altogether removed?

Mr. CRIPPS said it was a simple repeal, so that whatever quantity of sulphur might be contained in the gas they were to submit to in future. In all probability the quantity of sulphur would depend upon the coal that was used; and if it should turn out to be 60 or 70 grains, the answer of the company would be, "We have gone to Parliament, and they have expressly repealed, upon evidence, your protection; therefore, however great the impurity may be now, you are not entitled to make any difficulty

about it. Your time was to have gone to Parliament, and you had the opportunity of asking the committee not to pass the Bill. They have passed it, and you must now submit to that impurity, whatever it is." He (Mr. Cripps) would not at that time deal with the scientific evidence, because it would be obviously foolish to detain the committee twice over upon a question of that kind; but as the matter stood, had the company shown that it was a perfectly safe thing to repeal the restriction imposed upon them? If not, it unquestionably ought not to be removed. The whole proof was upon them to accept the restriction in return for benefits conferred upon them by the consumers. Was there anything sufficiently certain and definite shown that the gas consumers would not be prejudiced if a considerably larger quantity of sulphur was introduced into the gas? Sulphuric acid, no doubt, was generated by combustion. The amount of that, and the degree in which it was injurious to health, was very doubtful; and the witnesses said that in their opinion—and it was only a matter of opinion—it would not produce any inconvenience. On all those matters, science, even at its very best, was most uncertain; because, after all, it was not the quantity, however infinitesimally small any matter might be, which was detected by the experiment in a particular form, which was necessarily not injurious. Unquestionably, from the evidence as it stood, it appeared that in the gas supplied there was something very injurious, particularly at the top of the rooms, or at a certain height. Some persons thought it was carbonic acid; some thought it was something dry and hot at the same time. It might be that particular matter which they desired to have excluded; and when the height of rooms was spoken of, surely those who represented the consumers must be taken as representing all classes. In some cases, perhaps, persons were so careful of ventilation by modern appliances that the difficulty might be prevented, but that did not apply to the mass of consumers, who lived in small houses, and in rooms which were necessarily very imperfectly ventilated. Without detaining the committee longer, he (Mr. Cripps) could not help thinking that no case had been made out why the Bill should be allowed to pass, or why that which had been the law of the Metropolis for 17 years, and had prevailed against this company since 1873, was to be repealed in spite of the wishes, and against the remonstrances of the consumers of gas, who were the real parties to be looked to in any legislation on that matter. It was really a consumers question, and on behalf of those consumers, who were represented by the Metropolitan Board of Works, he decidedly asked the committee not to pass the Bill.

The CHAIRMAN (addressing Mr. O'Hara) said that Mr. Cripps seemed to ask the committee to decide at once that the preamble had not been proved, but they did not think they could do so, and therefore it would be necessary to go into the case somewhat more fully than Mr. Cripps had done. From the way in which the Bills had been brought on, the committee felt themselves bound to hear the present case upon its merits, and to decide it without waiting for the evidence and the arguments in the next case; but if the parties could make any arrangement by which the evidence taken in the present case could be made use of in the next, it would be a great convenience, and would save time and expense.

Mr. O'HARA expressed a wish to consult with his clients (the Metropolitan Board), and after a short conversation the committee adjourned.

WEDNESDAY, MAY 2.

Mr. *Charles Heisch*, examined by Mr. O'HARA.

I am a Fellow of the Chemical Society, and the superintending Gas Examiner to the Corporation of London. For 24 years I was Professor of Chemistry in the Medical College of St. Thomas's and Middlesex Hospitals. During that time I have been much engaged in the examination of coal gas and its impurities. Under the Metropolis Gas Act, 1860, the limit of sulphur impurity was fixed at 20 grains in 100 cubic feet. By the City of London Gas Act, 1868, which was originally intended to apply only to the City, but was afterwards extended to some other companies, the duty of determining with what degree of purity gas should be sup-

plied is in the hands of the Gas Referees, who are directed to fix such a maximum as the companies can comply with without creating a nuisance in the neighbourhood of their works. At the present time—*i.e.*, from April to September—they have prescribed 20 grains for works situated near habitations, and 15 grains for those which are more removed. The Crystal Palace District Gas Company are, by their Act, required to supply gas with not more than 20 grains of sulphur, and I think if that restriction were removed entirely, it would be a considerable injury to the consumers. Before 1868 the condition of the gas delivered in London was very variable indeed. Before 1860 I do not think any records were kept of the amount of sulphur impurity present in the gas. The Act of 1868 came into operation in January, 1869, but the Referees were more than two years before they fixed the maximum. I think it was fixed somewhere about April, 1872. For the winter half of 1872–3 it was fixed at 20 grains for suburban works, but no quantity was named for urban works until June, 1873. That was owing to the fact of the Referees being engaged in making experiments, and to give time to the gas companies to make certain alterations which they considered necessary. During that period, the sulphur impurity delivered by different companies varied very considerably. The Great Central, whose works were situate on Bow Common, delivered gas which may be roughly said to have contained an average of something like 12 grains of sulphur in 100 cubic feet. The City Company were higher, going up frequently above 20 grains. They seldom got up above 23 or 24. Sometimes there was a run up to 30, but very seldom. The Gaslight and Coke Company's gas, as tested at Leadenhall Street, generally had an average of from about 32 to 38 grains; and when the Beckton Works were opened, the averages were, during the month of January, 1872, 44·8, and during the month of February, 44·9, and during the month of March, 37·9. Then were was a sudden fall—the average for the next month being 22·9. Then it went up again somewhat to 37 and 38, and just about the time when the maximum was fixed it went down again; in June, 1872 it went down to 12·6, and the next month it was 12, and so on. That was after the fixing of the maximum by the Referees; but when the works at Beckton were first opened, they for the first three or four months averaged from 35 to 45 grains.

Mr. O'HARA: Is the presence of sulphur injurious to property?

Witness: I believe it to be very much so.

Mr. O'HARA: Will you explain your views upon that subject to the committee?

Witness: I believe it to be injurious to property in this way: Although the quantity of sulphur is exceedingly small, yet burnt in the way that it is in gas it is not oxidized in the same manner exactly as it is when it is burnt in a dry state. Very large volumes of water, or of the vapour of water, are formed at the same moment as the sulphur is oxidized from the combustion of the hydrogen in the gas. Now, it is well known that if you burn sulphur, even in a damp atmosphere, a certain portion is converted into sulphuric acid instead of sulphurous anhydride. Now with the very large quantity of water which is specially formed during the oxidation of the sulphur a very much larger proportion of the sulphur gets converted into sulphuric acid than it does when the sulphur is burnt even in a damp atmosphere, and of course much more than when it is burnt dry. All this matter ascends, and is trapped, as it were, in that heated zone of air at the top of the room, which Dr. Odling so very well described yesterday, and we have up there an aqueous vapour so far removed from its point of condensation as to be what would practically be termed dry, and we have the vapour of this mixture of sulphurous and sulphuric acid. When the fire in a room goes out, and it cools down, this aqueous vapour condenses, and carries with it certain proportions of sulphuric acid varying with the quantity of sulphur which is in the gas, and upon all the articles in the room where the moisture condenses (and the condensation naturally begins on metal work, which is colder, you have a quantity of very dilute sulphuric acid deposited. When the room is heated up again the water evaporates from that, and it becomes more concentrated, and you get a second dew the next day your gas is lighted, in the same way, and it gradually increases until, upon whatever

capable of containing moisture or of absorbing it—which is the case with leather and textile fabrics—you get a considerable amount of sulphuric acid concentrated in the material, and thereby increase the injury. We find, practically, that if you wash the surface of metal work which has been in an atmosphere where gas is burnt, you invariably get off a sulphate of the metal which you are using, whatever that metal may be. Moreover, if you wash out from textile fabrics the substance which they contain, you find a very considerable quantity of sulphuric acid in it.

Mr. O'HARA: Have you, since the maximum of sulphur was fixed, detected any benefit or any disadvantage to your own chemical instruments?

Witness: Certainly. I have no hesitation in saying that our delicate metallic instruments do not suffer in the City, now, as they did previously, or anything like those that I have at home do, where I get gas with about 25 grains of sulphur in it. I have been furnished with a valise by Jenner and Knewstubb, of St. James's Street, which has been on a shelf for about two years. I believe that there has not been a fire in the room, but there has been plenty of air. It was a well ventilated room, where they burn a good deal of gas in the winter time. Here is the leather which is outside, and which you will see has gone a good deal—it has been absolutely eaten away. Now in the interior, which of course has been subject to the same temperature as the outside, though not to the same influences, there is the leather as sound as possible. The outside and inside straps I have taken off for the purpose of experimenting with them, and they are not here; but the outside straps were corroded even more than the leather is; the inside straps were perfect. The outside straps, when boiled in water, yielded 2·4 grains of sulphuric acid, and each inside strap which was in a perfect state yielded 0·6.

Mr. O'HARA: To what do you attribute that 0·6.

Witness: I think it may have been that some air got inside from the room, or it may have been that a certain portion of sulphur might have been used in the dressing of the leather.

By the COMMITTEE: The 2·4 and 0·6 grains are the absolute quantity I got from each strap. The straps are the same length exactly, and they had every appearance of being cut off the same piece of leather. This valise has not been exposed in any way, in travelling or otherwise, from the time I got it. It is a piece of spoiled new goods, and has never been out of the shop. It only came to me the day before yesterday.

Mr. PHILBRICK: This is something that you bought recently?

Witness: I did not buy it, they furnished me with it; it has been on the shelf at Jenner and Knewstubb's shop, and I can bring the foreman here if you wish to see him. There is another point to which I should like to call the attention of the committee; which is, that the quantity of sulphuric acid which you are capable of condensing along with the moisture increases very rapidly with the increase of sulphur. When vapours are very much diluted they are much more difficult of condensation than when they are a little stronger, and I found, experimentally, that from the gas with which I am supplied at home—perhaps I had better describe exactly what I did. My gas is supplied by the West Kent Gas Company. They are under the 20 grain restriction; but it is not looked after, and practically I find that they give us from 21 to 25 grains of sulphur—that I have tried. Now, what I did was this—I lighted a 4-feet burner in a small room, a room containing about 290 feet of cubical contents. I burnt this 4-feet burner for two hours; consequently, of course, I used 8 feet of gas; and I then put into the room a flask filled with ice, for the purpose of condensing the moisture which the gas had formed in the room. I left that in for three or four hours more, so that from the time the experiment was started to the time it closed 20 feet of gas had been burnt, which would contain nearly 4 grains of sulphur. The room has a window which fits very badly, unfortunately. It is a room with a boarded side, and there is a considerable crack in the boards, so that there is by no means an absence of ventilation in it. I repeated this over three or four times, and by collecting the water which was condensed on the outside of the flask, I found that on a half-gallon flask I could collect in that water from a quarter to half a grain of sulphuric acid. I have repeated the same experiment in a similar small

room, which I happen to have in the City, with gas which, at that time, contained about 8 grains of sulphur in 100 cubic feet; or, at all events, under 10 grains, and from that, proceeding precisely in the same way, I could collect as a maximum only 9-100ths of a grain of sulphuric acid; that I believe to be due to the much greater dilution preventing its condensation. But, out of those two experiments, the one was 9 100ths, and the other of the two was only 5-100ths of a grain, whereas in the first we got from a quarter to half a grain, where the quantity of sulphur was doubled.

Mr. O'HARA: What deductions do you draw from those experiments?

Witness: Certainly, that the sulphur ought to be kept down to as low a point as possible.

Examination continued: There are still some companies under the Act of 1860. One of them is the Phœnix, at Greenwich. As a rule they comply with the 20-grain condition. I have tested for it; and in complying with the condition they do not create a nuisance. I lived for upwards of 40 years very near them, and I never heard of one, nor have the authorities of Greenwich ever heard of one either. I scarcely know, of my own knowledge, any other companies in the country that have gas works and keep a low average of sulphur without creating a nuisance. I know, of my own knowledge, that they do keep under 20 grains at Bath, and I am informed by the local authorities there that they have never heard of any nuisance, but beyond that I cannot go.

The CHAIRMAN: Do you happen to know whether in all those cases they use the lime process?

Witness: Yes; they do.

Mr. O'HARA: Is it your experience, or is it your view, that this lime process may be conducted without creating a nuisance?

Witness: I believe that it may, but not being a practical gas maker I cannot go so far as I otherwise might; but I believe it may, because I believe that it is done. During the time that I lived in the Phœnix Gas Company's district, or part of the time, the sulphur was not kept very low, but lately it has been kept down very well indeed, until within the last week or two. They are now altering their plant, and have been obliged to pull down some of their purifiers; and at the present moment (viz., it was a few days ago, rather higher, but that is accidental. A part of the district supplied by the Phœnix Gas Company is within my observation as gas examiner. Therefore, I am tolerably well acquainted with the capacity of the works, and the results of their operations.

Mr. O'HARA: Are you of opinion that the responsibility of the penalty which is imposed upon a gas company—in this Crystal Palace Gas Company case—is a matter that you approve or disapprove?

Witness: I should certainly be very sorry to see it removed altogether, taking the consumers' view of the question.

Cross-examined by Mr. [illegible]: From the Metropolis Gas Act, 1860, the Gas Works Clauses Act of 1847 was the general law throughout the country, and there were then no restrictions as to sulphur compounds. The first restriction in the Metropolis was in 1868. My [illegible] as the City only began under the Act of 1868. Before that it was a matter of scientific research. I put that experiment in the pamphlet.

Mr. [illegible]: Between 1860 and 1868 that is the time when London was under the Act of 1860 was there any particular trade complaining or complaint of any one of the gas companies with regard to the sulphur compounds on the part of any of the authorities?

Witness: There was an attempt made in the City, which I believe at that time were the only authorities that had an Act giving [illegible] to the use of jurisdiction. It never was [illegible] to be [illegible] at all. There were actions proceeding [illegible] one was the Crystal Palace, and the other was the Gas Light Company, which I was then [illegible] for sulphur compounds.

Cross-examination continued: [illegible] sulphur compounds before 1868. We were always obliged to have [illegible] their existence [illegible] to be known [illegible] to be known as [illegible] as any [illegible] was [illegible] certain [illegible] quality. [illegible]

sulphuretted hydrogen was a matter of ordinary chemical knowledge that dates long before chemistry reached its advanced state as a science. Sulphuretted hydrogen at that time was taken out of the gas by means of lime, and until the discovery of hydrated peroxide of iron that was the only means of removing it. I am not aware, of my own knowledge, that there were ever any legal proceedings taken by private consumers in the City, under the Act of 1860, in reference to the sulphur compounds. There were, I believe, numerous complaints sent in to the Corporation as to damage done to goods, with requests that they would take action. The testings by the Referees are now made on an average of three days; they used to be taken for each day.

Mr. PHILBRICK: Is it not a matter of fact that two testings hardly ever agree, even by your own examiners and with the same gas?

Witness: Within very narrow limits.

Mr. PHILBRICK: But as a matter of fact, the same examiner, with the same test apparatus, dealing with the same gas, does not ever get to identically the same results?

Witness: I would not say never, but not always.

Do you remember a case where it has ever resulted that a gas examiner has got identically the same results—I will go so far as that?—I think I can remember a great many when we have had two apparatus working simultaneously side by side.

That is two instruments side by side; but I mean when the examiner has repeated the process with the same gas?—I do not exactly know how you could do that.

I do not mean where he is conducting two operations simultaneously; but where he has completed his tests, one after the other, with the same gas, supplied by the same company, is it not the fact that the tests do differ?—We cannot do that; we cannot get the same gas two days running from the same company.

I am talking of two hours running?—The sulphur test is a test extending over 24 hours, one test; so that we can never have the same gas two days running.

You know the test, as I understand; I mean in the testing process as directed in the Act of Parliament, and kept by the companies, and by which, by the provisions of the Act, the companies have agreed?—Yes.

Is it not a notorious fact that the tests made by the officers of the companies, in this matter of sulphur compounds, never correspond to the tests of the gas examiner, that there always is a discrepancy?—I am not prepared to admit that at all. They are frequently in accord, and very frequently not; but then it must be remembered that the gas companies test at the works, and we test a mile away from the works—1000 yards it is called, but it is practically nearly a mile.

The nearer the works so the greater ought to be the proportion of sulphur, ought it not—there would be a certain condensation through the pipes, possibly?—There might; or if the pipes were foul they might take up some.

But the tendency would be, would it not, if there was a difference between the two, to show the presence of a greater quantity near the works than at a distant place away from the works?—That might be so or not; it would depend upon the state in which the mains were.

As a matter of fact, the tests of the gas examiners are in excess, as a rule, of those of the company for sulphur, are they not?—I have heard it stated occasionally that they are; but I have also been told that they agree very fairly, taking it altogether, because the tests made by the companies testers I know nothing about officially at all—it is mere gossip with me what their testings are.

Cross-examination continued: The shop in which the portmanteau produced was kept for two years is supplied with gas by the Chartered Gas Company, who, as far as I know, have kept well within the sulphur maximum prescribed by the Referees. The straps which I removed were boiled in water in a glass vessel. A very large proportion of the sulphuric acid obtained by that process was in the form of free sulphuric acid, but I did not make any distinction between that which existed as one or the other. I only took the relative quantities in that which had been exposed

and that which had not been exposed, and a highly acid solution came out.

Mr. PHILBRICK: Now, is not there always in leather the presence of some acid?

Witness: Of some acid; yes.

So that, therefore, you began your experiments with something that had got in it that which you were professing to want to find? You took a body that had got a constituent in it that you wanted to find—when you began to experiment with leather that was corroded you began to experiment with a thing which anybody, *à priori*, with a little chemical knowledge, could tell you had got the presence of acid in it?—Yes.

Then if you have the presence of acid and sulphur, or if you have sulphur in any form, you can always safely say that there is sulphuric acid in it, can you not?—Oh, no.

How can you tell what quantity there is? How can you tell that there is any free sulphuric acid?—The acidity is so much more marked than it would be from other acids that I think there is no question about it.

Then because the acid tasted a little sharper in the straps of the portmanteau, you therefore concluded that it was free sulphuric acid, and you put it down to the gas. Is that the chemical result which, as a gentleman of science, you are prepared to vouch here?—I do not feel any doubt about it at all.

Into questions of doubts in your mind, if you will pardon me, I will not enter before the committee; I want the question of chemical science, and fortunately I have the assistance of a gentleman who is able to keep me right?—In this particular instance I did not estimate the free sulphuric acid, but I have so often found free sulphuric acid under similar circumstances, about which I have not the slightest doubt, that I did not go into it in this particular instance. I merely took the comparative quantities of the two straps.

In giving the instance before the committee, I presume you were examined upon it, on the part of the Metropolitan Board, to bring about certain results. I will not go into any other cases than the one before us. Let me ask you, as a scientific man, how, as a chemical result, you can undertake to affirm that there was present in these straps free sulphuric acid?—I confess that I have made a slip upon that point on this particular occasion.

Mr. PHILBRICK: You shall pack up that slip in your portmanteau, and take it away.

Cross-examination continued: The experiment which I made in a little room at my house which contained 290 cubic feet of air, and in which I burnt the gas with a 4-feet burner, and condensed the vapour upon an ice vessel, was repeated by me in the City with the gas supplied by The Gaslight and Coke Company, who at the present time keep well within the restrictions of the Referees as to sulphur compounds. That room was rather less than the other. It was not without ventilation; it had no chimney, but was by no means hermetically sealed. The quantity of sulphuric acid I then obtained was very minute in any form.

Mr. PHILBRICK: Now it seems to me (I may be ignorant upon the matter) that if the West Kent Company were working down to about 20 or 25—your phrase is—and even to 30 grains of sulphur per 100 cubic feet, and the general result was half a grain, you ought to get from one-eighth to one-quarter if The Gaslight and Coke Company were working with half that quantity?

Witness: Not at all; but that is just the point that I want to bring out—that the sulphuric acid, however it may be in the vapour, is much more easily condensed when it exists in a larger quantity. Although the gas may really contain twice the sulphur, the condensed water will contain a great deal more of the acid produced by its combustion than twice the quantity, simply because, where the vapour is very diluted, it is much more difficult to condense; we have a number of instances of that.

I thought that condensation was dependent upon the temperature, and not upon the volume. What is the boiling-point of sulphuric acid?—I really forget—something between 300° and 400°.

Nearer 600°, is it not?—I suppose it is, but I really forget at this moment.

It is not between 300° and 400°, but nearer 600°. You say that it is more difficult to condense vapour that is in a more liquid form?—That is mixed with a very large quantity of other vapours, such as a very large quantity of the vapour of water, and a very large quantity of atmospheric air, and so on.

You mean to say it is difficult to condense the contents of a product, or difficult to condense the constituents of that product and separate it?—I mean that the same temperature would not produce the same amount of condensation relative to the contents.

If you say that there is a great difficulty in the condensation, is not that condensation the mode of test which the companies have for these sulphur compounds, and which they have to comply with under penalties?—That is by condensation in rather a different sense of the word; it is by condensation in condensing with alkali, and not attempting to condense it as it exists.

Have you, for the purposes of the experiments that you have been detailing to the committee, adopted a different mode of test to that which the Referees prescribe?—I was not simply testing the sulphur in the gas, but estimating the amount of sulphuric acid condensed on a cold article in a room in which gas had been burning.

And therefore arriving at the conclusion that whatever you condensed in the room on a cold surface, or a vessel filled with ice, must necessarily be due to the gas?—Not absolutely.

Cross-examination continued: I believe the Phœnix Company used lime exclusively for a very long time before oxide of iron was introduced. I left Greenwich in 1869. I do not know whether that was before the necessity for using lime again commenced. Gas is generally burnt in workshops, but I cannot answer the question whether it is rarely burnt in the dwellings of artisans in London. I regard the sulphur compounds as a nuisance which ought be eliminated as far as possible. Where gas-works exist in crowded places there is a difficulty in the removal of these compounds by means of lime; I do not say it is an insuperable difficulty. I said that, as a matter of observation, there is sulphuric acid found upon metal surfaces, varying in proportion to the sulphur compounds in the gas. What I mean is this, that, if you take metal-work which has been exposed to gas containing a great deal of sulphur, and that which has been exposed to gas containing very little sulphur, the same quantity being burnt in a room, you will find a great deal more of that metal converted into a sulphate in the one case than in the other. I believe this has been detected where 35 grains of sulphur compounds per 100 cubic feet have been present as against 15 grains. I think I could point to several cases in my own house. I have frequently washed off the sulphates of the metal from the surface of the metal-work. It must be sulphuric acid to make a sulphate of the metal. I refer principally to fine polished brasswork, and things of that sort; the brasswork of one's instruments, which do not have to be cleaned with preparations containing acid.

Mr. PHILBRICK: Seriously, are you meaning to represent to the committee that you can differentiate between what you wash off when you have been burning 30 grains of sulphur compound in 100 cubic feet of gas, and another quantity—a less quantity?

Witness: No, I do not mean to put it in that form; but I do say distinctly that I can, with the gas with which we were supplied in the City, freely expose delicate instruments in a way that I cannot do if I burn gas at home.

Re-examined by Mr. CRIPPS: I understood Mr. Philbrick to ask whether the quantity of acid bore any proportion to the quantity of sulphur existing in the gas, and I say that I find practically that it increases more rapidly than the increase of the quantity of sulphur. As an abstract proposition, I assent that it would be desirable to eliminate the sulphur compounds, if it is possible without creating a nuisance. Assuming it to be a nuisance, however, it is a nuisance limited in its operation to a certain number of persons resident in the neighbourhood of the works, whereas the benefit to be derived from taking it out of the gas is a benefit to the whole of the consumers.

Mr. CRIPPS referred to the examination of some of the witnesses before

the Select Committee on the City and Metropolis Gas Bills in 1866-7 to show that complaints had been made, subsequent to the Act of 1860, of the impurity of the gas supplied in parts of the Metropolis. On his proposing to read a part of Dr. Letheby's examination,

Mr. PHILBRICK objected, and said: Dr. Letheby, we know, altered his mind before he died.

Mr. CRIPPS claimed his right to quote it, as the evidence on these Bills had been referred to this committee.

Re-examination continued: I have no doubt that sulphuric acid has helped very considerably to effect the corrosion of the leather of the valise I have shown here. I do not say there would have been no corrosion without it. I am not able to say that some other compound may not possibly have had to do in effecting it, but I know that sulphuric acid has been present, and has had its share in doing the mischief.

The CHAIRMAN: Besides the injury which you suppose is done to the brass and to the leather by this sulphuric acid in the gas, do you think it does any harm to human health or life?

Witness: I could not speak very positively—my own impression is that it does irritate the breathing organs and the eyes; but I could not speak positively on that point.

In any appreciable degree, do you think?—I think so, but I would only give that as an individual opinion.

You do not know any instance in which you have traced, to your satisfaction, to that cause, irritation of the eyes?—I think I may say to the use of gas; but I would not say positively to the sulphur in the gas. I could not go to that length.

Mr. PHILBRICK: I may mention that Dr. Letheby, in the evidence that my learned friend has read, expressly said that it did not affect human health. He said that he could not say it affected human health.

Mr. CRIPPS: It is only fair that I should read this; he is asked whether these compounds are not pernicious, and then the question is put: "Because it forms sulphuric acid, or oil of vitriol, which destroys fabrics?—*A.* That is so; it quickly becomes sulphuric, it first forms sulphurous acid, and this, by taking more oxygen from the air, becomes sulphuric acid, or the acid sulphate of ammonia, which is very corrosive, and rapidly destroys fabrics; we have seen so much of that, that there can be no question about it, whatever theory may be formed of the nature of the compound, that is a destructive agent. *Chairman:* Destructive of what?—*A.* Of all kinds of textile fabrics, especially to paper, linen, leather, and also to brass-work. I know that unlacquered brass-work will not stand as it did formerly; it cannot be exposed for any time to air without undergoing corrosion. *Q.* And human health?—*A.* I do not think it affects human health much." That is the exact answer?

Witness: That is all. He does not say that it does *not* affect human health, but he says he does not think it affects it much.

The CHAIRMAN: Do you know what was the nature of the complaint on which the legal proceedings were taken by the City, which you mentioned against the gas company? What was it that they complained of exactly?

Witness: Their complaint was an excess of sulphur over the 20 grains allowed by the 1860 Act.

Mr. *Thomas William Keates*, examined by Mr. CRIPPS.

I am consulting chemist and superintending gas examiner for the Metropolitan Board of Works, and consulting chemist to the River Lea Conservancy Board, and have had very large experience. For some years past I have been very much engaged in investigations as to gas matters in the Metropolis, and was for two years also chemist to the City of London Gas Company.

Mr. CRIPPS: Let me direct your attention to the main point I want to ask you about. Of course, we assume that the only reason why this impurity should not be removed is the probable nuisance being created by the lime purification?

Witness: Yes.

Has your attention been specially directed to that question with a view of seeing whether that nuisance could be removed or mitigated that is

the nuisance created at the works by the purification?—Yes, I have had opportunities of examining that question, and I have considered it very much, and I am of opinion that the nuisance has been greatly exaggerated and that the removal of sulphur could be effected to a moderate extent without creating any nuisance. It would, of course, mainly depend upon whether the lime, which has been used at the works for purification, could be removed without a nuisance.

First of all, what have you thought with reference to the possibility of disinfecting or mitigating the unpleasantness of the compound in the purifiers, which is made of the lime, for the purification of the gas?—I think that can undoubtedly be done. When the inquiry was going on before the Commissioners for the Board of Trade some years ago, I produced lime that had been disinfected in the purifiers, and that lime was completely inodorous; there was scarcely more smell in it than in a piece of chalk. And last year I had occasion to visit the works at Bromley. I was there with the late Dr. Letheby, when one of the large purifiers was opened. I then took a quantity of lime from the different shelves of the purifiers, and examined that lime, and found that it was quite disinfected. The noxious material in the foul lime has been already stated to be sulphide of calcium, which is an active principle used in taking out these sulphur compounds. That sulphide of calcium is a very foul, stinking material, and on this occasion I found that it was almost entirely removed from the lime.

Mr. PHILBRICK: I do not like to object to my learned friend's line of examination of Mr. Keates; but I must remind the committee that the allegations which are made on the part of the Metropolitan Board are not that any nuisance that is now existing, or might exist, from the impurity of these articles, can be removed or mitigated; but that the allowing of the presence of these sulphur compounds in gas would be very prejudicial to the sanitary condition of the district.

Mr. CRIPPS: Then that raises the whole question. The answer to that is that it cannot be done because it creates a nuisance, and the rejoinder to that is that it can be done without creating a nuisance.

Mr. PHILBRICK: I will not press my objection.

Mr. CRIPPS (to witness): Will you go on with what you were saying?

Witness: I was stating that the lime removed from the purifiers was completely disinfected, and I understood that that process was in current use. It had been first rendered foul, so as to make it capable of taking out the sulphur compounds. I think there are three different methods by which it can be done—one is by passing air through the foul purifier; another by continuing to pass crude gas through until the lime is converted into carbonate of lime; and it can be done by passing the products of gases from a furnace through the purifier—that was an invention which I think was used by Mr. Mann at the City of London works, and was patented by him—*i.e.*, passing the heated gases from a burning furnace through the purifier so as to use the carbonic acid which was produced by the combustion for decomposing the sulphide of calcium and producing carbonate of lime. As far back as 1859, I think, during an inquiry in connexion with a Bill promoted by the City of London Company for a new charter, strong evidence was given by many scientific witnesses upon the point that lime can be converted into carbonate without difficulty, and can then be removed without being at all a noxious thing.

Assuming that it were possible in either of those ways to do it, that probably might involve increased expense?—I do not know, but I think the companies are mostly prepared to do that at the present time. I know that it has been put forward as a plea that in some cases the companies were making alterations in their purifying plant, and when those alterations were completed, they would be able to carry on those processes.

But setting aside any question of expense, of course you will probably say that, if it can be done, the consumers are entitled to insist upon it?—I speak of the thing as a chemical fact more than as a question of anything else.

Now, if that were done, would the lime when it came out of the purifiers be free from that noxious smell which it has at the present time?—Comparatively free. No materials in a gas-works can ever be turned out quite

free from smell; they all carry with them their characteristic odour of gas, and so far as I am aware nothing will remove it entirely. That applies to everything. Oxide of iron, which I believe is supposed to be a perfectly innocuous thing when it gets out of the purifiers, has that peculiar gas smell which cannot be got rid of so far as I know.

Probably it could only be mitigated, at least in the gas-works, being in in a part where the population is not very thick, and removed as far as it can be?—I suppose that is the only entire remedy for it.

That is a matter that has been going on from year to year for some time past?—Yes, now some of the larger gas-works are removed from London. The largest gas-works, the Beckton Gas-Works, are some miles down the river; the Bromley works have also been removed from the neighbourhood of houses.

What you suggest would remove the special difficulty supposed to be created by lime purification?—Yes, the lime purification *quoad* this particular question.

Would it at all prevent the lime being used, as it is used now, for taking out the sulphur compounds ultimately?—The sulphur compounds are taken out by lime, the sulphuretted hydrogen is taken out by oxide of iron, and to that extent it would remain as it is; the oxide of iron would still be used partially.

Cross-examined by Mr. PHILBRICK: It is necessary to use the lime in the second set of purifiers, if you adopt Mr. Patterson's mode, in an exceedingly foul state, so as to absorb these other sulphur compounds. I know that passing air through the purifiers has been tried at Bromley, and that the actual effect of doing it was to produce an explosion; but will you allow me to explain? I am told that that has happened, and I can easily believe it is so, but it does not follow at all that that system might not be improved so as to avoid this difficulty. I may say that when I was at Bromley, on the occasion that I mentioned before, they were passing air through one of the large purifiers then; they had been passing crude gas through the purifiers for a considerable time, until they had converted all the lower layers into carbonate of lime from the carbonic acid in the crude gas. Then they had reversed the process and had passed air downwards, and by that means they had converted the upper layers of lime chiefly into sulphate of lime, and there the process was going on, and I did not understand that there had been any difficulty about it.

MR. PHILBRICK: Did you hear of the fact that the trays had been set on fire?

Witness: I admit that may be the case; when rapid oxidation goes on, you are subject to that sort of thing, but I do not admit that it cannot be remedied.

At the present moment Bromley is the only place where that system of driving the air through the trays of the purifiers has been attempted?—There was some system of the kind, I cannot tell what exactly, in operation at Fulham some time ago. I know that Fulham has always been bitterly complained of; but it does not follow that the cause of the complaints might not be remedied. I had occasion to go to Fulham some two or three years ago in consequence of a nuisance. I was instructed by the Board to go and see the works, and I went and I found that that complaint did exist, but I was told in the works that it would be very soon remedied. I made a report upon it at the time. The second mode I mentioned was passing crude gas through. That is the method by which this foul gas is made in doing that to extract the sulphur compounds. I do not know that it is practised to the extent of going so far as I am saying. It can be done without difficulty, and it was done in the case that I spoke of in one of the purifiers at the Imperial works, and there the change was most effectual, and I found 90 per cent. of carbonate of lime. The effect of that is to carry the sulphur on in the gas necessarily, but then you see, according to this system of purifying gas from the sulphur compounds, it is a necessity, and the passing on of this sulphur becomes a useful thing, and not a detrimental thing, because it can be employed in converting fresh portions of lime into foul sulphide, which will afterwards act upon the sulphur compounds. In a sense the effect of it is to postpone, in one stage of the process, the purification.

Now the third one, in which you drove heated air from the furnace through the purifiers, is a process which has never been carried into effect at all?—I do not think it has, but it was advocated by one of the most practical engineers of the day—Mr. Mann, of the City of London works. He never carried it into execution himself, and nobody else has adopted it.

Did you test for these other sulphur compounds on the part of the gas company as against Dr. Letheby when he was testing on the part of the City?—I did.

As a matter of fact, let me ask you, in testing for them with this operation of nicety, did your tests practically agree? Was not there considerable discrepancy?—I do not think there was. There were occasional discrepancies, and very large discrepancies; then the thing was brought to a test on a particular occasion. There were continued disputes, I may say, between the company and the corporation at that time. On one occasion I went to the London Hospital, and Dr. Letheby went to the works; Mr. Warrington, of the Apothecaries Hall, went to my laboratory in Blackfriars, which was at that time the last place on the gas-mains. I may say it was in reference to the Great Central Gas Company that these disputes were arising, and then, by-the-by, I was testing for them, and not for the City of London Company; but on this occasion, some five or six of us made a similar experiment at seven o'clock in the evening, and we got exceedingly coincident results.

You got coincident results; but prior to that time when you had been testing, or assuming to test, the same gas, were there coincident results?—I tested the gas of the City of London Company for several years, and there were occasionally very great discrepancies between myself and Dr. Letheby.

Do those discrepancies arise from errors on the part of the observer, or from that which is inherent in the mode of testing?—You ask me a question that I cannot possibly answer. With regard to the errors on the part of the observer, I cannot tell you about that; I can only tell you that I think I was right. It is not a delicate operation to test for these other sulphur compounds. It is an operation that is carried on in some places in London every night. I am willing to admit that you never get exact concurrence, but you get it so close that you may take the result as being practically true.

Now just as to this matter—as to the presence of these sulphur compounds in the gas—supposing there to be, I will assume, 20 grains, which is the limit—in order to get 20 grains you have to work to a minimum—you have not much less than that in practical gas-making?—I suppose you have to have a margin of safety.

Practically you require 20 grains, in order that the gas-maker may be safe; he has to work down to 15?—He would have necessarily to work to something less.

Now take the gas which would be supplied under a restriction of 20, and which would be 15 or 16, or whatever it might be; and take a gas which had 30 or 35 grains of those other sulphur compounds in it per 100 cubic feet. Do you say, as a gentleman of experience, that practically to a consumer burning that gas there would be any real difficulty or difference?—I am myself rather in favour of relaxing the limit. I think that a little above 20 grains may be allowed, but I think that it would be the greatest possible mistake to remove the restrictions altogether.

How much would you give, then?—I think even 25 or 30 grains might be allowed, but I think that there ought to be a strict limit put upon it.

With regard to the limit, that is a matter of policy and discretion, but with regard to the 30 grains, you would say, as I understood you, this—that if the process of purification by lime can be conducted, if proper appliances be used, without creating a nuisance, you still say it is not weighing one nuisance against the other, but you say you would not object to even 30 grains of sulphur in 100 cubic feet of gas, in the interests of the consumer?—I think it would be straining the thing in favour of the company; but when you consider the expediency between a nuisance created and an advantage to be gained, I think that 30 grains may be allowed.

You say that would practically bring it down to 25?—That is the way you put it; but I do not think it is so really.

In order to get at the limit of 20, you will have to use quite as much lime as if your limit were 30, would you not?—I think certainly not.

You would have to put not quite so much lime, but you would have to have as large a surface of lime at a time employed?—Even supposing that was so, that would make a great deal of difference in practical gas-making in the works.

Cross-examination continued: I have said, in a letter which has been published, "It will be seen that the talk which is made about the sulphur in the gas is, after all, practically a thing of very little, if of any consequence from a sanitary or economical point of view." My opinion is not in the least changed as far as all that goes. Bisulphide of carbon has been actually burnt in a lamp specially contrived by me, and used for disinfecting and antiseptic purposes. The bisulphide of carbon is a compound of sulphur which in burning gives off an enormous quantity of sulphurous acid. Some time last year a paper of mine was published in the *Lancet*, recommending the use of bisulphide of carbon to be used for disinfecting purposes; but if you put a lamp here, containing bisulphide of carbon, which is a liquid like spirits of wine, it would be impossible for you to stop here after a minute or two. It is the same thing that you get when you burn sulphur. If you burn a quantity of sulphur, you very soon bring the atmosphere into a state in which you cannot breathe, and that is just what happens when you burn bisulphide of carbon.

Re-examined by Mr. CRIPPS: Bisulphide of carbon may be very useful as a disinfecting agent, but extremely disagreeable. There is no comparison between the things—not the slightest; if you light a brimstone match, and hold it to your nose, you will, in fact, be getting sulphurous acid. The testing under the Act of Parliament for sulphur compounds is not one testing only, but since last year the average testing of a day. In the case of a penalty the average of three days must be taken.

Mr. CRIPPS: That is with regard to the Chartered Bill, is it not?

Witness: Yes; I was thinking of the law in the Metropolis. I do not know how that is in the Crystal Palace Act.

Mr. PHILBRICK: It is a simple testing in our Act.

Mr. CRIPPS: If it is so, I am wrong.

Mr. PHILBRICK: In our case it is a single test on a single day, one test on one day, and we have had to pay the penalty.

Witness: It does not say anything about the average of any number of testings. It cannot be otherwise, because the testing for sulphur occupies the day; therefore there cannot be any average of testing, the test is going on during the whole day—it is continuous. It is continued for about 20 hours—the gas must burn that time.

Mr. CRIPPS: You say very properly that for the purpose of avoiding a penalty, the care to be taken at the works would always go somewhat beyond the exact amount of the penalty?

Witness: It must do so just exactly in the same way gas companies are obliged to give something above the illuminating power in order to secure the minimum.

Whatever that amount may be does not matter exactly. Now with reference to what I asked you in chief, and what my learned friend has been upon, about those three modes of purifying by lime, which is an important point. He puts it to you that by passing in the air, on some particular occasion, an explosion was produced. I understood you to say that that explosion is not a necessary effect of what you suggest should be done?—The explosion, I take it, happened in this way. The air passing into the purifiers expelled the sulphuretted hydrogen, which is a combustible gas, and when sulphuretted hydrogen is mixed with a certain quantity of atmospheric air it becomes an explosive compound; and what happened, I take it, was this, that, as the lime was passed into the retort, it discharged the sulphuretted hydrogen, and this, being mixed with the air, went into the furnace, and an explosive mixture necessarily was formed, and it exploded. I do not know, but I should think, as an engineering question, that that difficulty might be got over in this way, that these gases might be passed through a sort of supplemental oxide of iron puri-

fier which would take out the sulphuretted hydrogen at once; and, therefore, it would not be necessary to burn it at all. The accidental occurrence of that explosion does not alter my opinion about the feasibility or practicability of the thing.

Mr. PHILBRICK: It was the air going through the oxide in this case, I am told.

Witness: Of course, I do not know; but I do not see what the air going through the oxide could have had to do with the defœcation of the lime purifier; it does not relate to these matters at all.

Mr. CRIPPS: You consider that that could be done?

Witness: I think that it could be; it appears to me the only difficulty is an engineering difficulty, which might easily be got over.

Then, again, with reference to putting gas through, it is put to you that that would postpone the process of purification—would that signify at all?—No; I think it is very much a question of space; I suppose that is one of the great difficulties that gas companies, particularly London companies, have been always placed in; the want of space for extending their purifying plant; but that certainly would not apply to companies outside, where they have abundant space.

The CHAIRMAN: Do I understand your evidence to be that you hold that the difference between 20 and 30 grains of these sulphurous compounds does not make any substantial difference to the injury done to leather, metals, and so on?

Witness: Of course, whatever difference it would make, the effect of sulphur is, no doubt, in exact proportion to its quantity; therefore 20 grains produce a certain quantity of sulphurous matter in the atmosphere; 30 grains would produce one-half more; and, therefore, whatever the effect of 20 grains would be, the effect of 30 grains would certainly be greater in that way.

Do you agree that the presence of this sulphurous matter in the gas which we burn has to any extent an injurious effect upon pieces of leather?—I think that question has been very much exaggerated. There is no doubt at all about the fact that you actually find sulphuric acid in things that have been long exposed to the action of gas. I have taken down for the purpose of experiment, within the last few days, a line which has held up a picture for a great many years in a room. I thought it was fairer to examine that than it would be to examine leather, which is sometimes treated with materials containing sulphuric acid in some form. I have examined this line, and I find it does contain sulphuric acid in a small quantity; it contains sulphuric acid in the free state—some portion of it is neutralized, and some portion of it is in a free state, but you can obtain from this piece of material, without the slightest difficulty, indications of sulphuric acid. That piece of line had been up for a long time. I cannot remember in the least when it was put up, but I think it must have been up 20 years; it has been hanging in a room in my house, and I thought that that was a good material to experiment upon.

Might I ask you, with regard to the sulphurous compound or sulphuric acid, do you believe that the presence of the sulphurous ingredients in the gas is injurious to human health or life?—No, I do not, in the small quantity in which they exist.

Do you believe that the other one—the nuisance of the sulphide of calcium produced by the lime process—is injurious to health or life?—No; I do not think it is. It is a foul thing, and it is a very offensive thing; but I never have known cases of damage to health that could at all be attributed to the effect of gas-works. I think rather the reverse is the case. In inquiries that have taken place, I think it has always been shown that gas-works are ordinarily healthy places.

Mr. PHILBRICK (through the committee): Will you tell us whether in that room where the line was, there was gas burning, or only a coal fire?

Witness: There were both; it was a little library in my house at Dulwich, which is lighted every night with gas.

Dr. *Edward Frankland*, examined by Mr. O'HARA.

I am a Professor of Chemistry in the Government School of Mines, and also a Doctor of Philosophy, a Doctor of Common Law, and a Fellow of

the Royal Society. During the greater part of a quarter of a century I have frequently been called upon to make investigations connected with the manufacture of coal gas, and I have had many opportunities of inspecting gas-works, and have seen the processes carried on there. Besides sulphuretted hydrogen, crude coal gas contains bisulphide of carbon, or bisulphuret of carbon, as it is frequently termed. The other compounds contain both sulphur, carbon, and hydrogen, and all those compounds when burnt alone yield practically the same products of combustion—that is, chiefly sulphuric acid and partly sulphurous acid. Until about the year 1856 the purification of gas was effected by means of lime. I think that was about the time that the change took place. The purification by lime removes not only the whole of the sulphuretted hydrogen present, but also a large portion of the other sulphur compounds—the bisulphide of carbon and the sulphur organic compounds as they are called; whilst peroxide of iron removes only sulphuretted hydrogen. My experience would lead me to say that, under the lime process, the number of grains of sulphur in 100 cubic feet of gas would, on the average, rarely exceed 15. I mean to say that the quantity of bisulphide of carbon and other sulphur compounds, other than sulphuretted hydrogen, will not contain more than 15 grains of sulphur to the 100 cubic feet of gas after purification by lime. The peroxide of iron system leaves a quantity varying from about 28 or 30 grains to 40 grains of sulphur per 100 cubic feet. Perhaps I ought, in completion of the answer to your former question, to add that the proportion of those sulphur compounds in gas depends very much upon the way in which the gas is manufactured. If the gas is manufactured at a very high temperature, by which a large quantity of gas is produced of a lower illuminating power, there is always much more of those sulphur compounds than are present when the gas is subjected to a lower temperature, so that it will necessarily vary in different gas-works. During the combustion of coal gas a considerable portion of the sulphur is converted into sulphuric acid and the remainder into sulphurous acid, but this sulphurous acid, diffusing itself through the atmosphere of the room, passes very quickly into sulphuric acid, and I should say that for all practical purposes it may be held that in a room in which gas is burnt freely in the open air of the room, all the sulphur passes into the state of combination known by chemists as sulphuric acid, or oil of vitriol; and 100 cubic feet of gas containing 40 grains of sulphur would produce, when burnt, rather better than 122 grains of oil of vitriol.

Mr. O'HARA: Now, what becomes of the oil of vitriol?

Witness: As oil of vitriol cannot exist as a gas at the ordinary temperature of a room, it condenses to minute drops—to the very minute kind of drop that you have in a fog—and floats about in the room until it is either removed by ventilation or attaches itself to some object in the room. Those minute drops are too small to be seen by the naked eye, except under favourable circumstances. You can see them if you pass a ray of sunlight through the room, or a ray of electric light; you can see that the air is filled with minute drops of something; but then, as there are so many minute drops of other kinds of liquid, I do not mean to say that you can see the sulphuric acid drops amongst the others. These drops attach themselves to walls, furniture, decorations, and so on. They destroy books, and corrode gilding and paperhangings, and so on. They perform all those reactions which are well known to follow the application of sulphuric acid. I may mention, as a matter of my own experience, within my own house, during the last few years, that I have found the bell cranks to be very powerfully corroded in the butler's pantry, where those bell cranks are placed near the ceiling, and therefrom get rather a large dose of the sulphuric acid so produced by the gas. Those bell cranks, being corroded, stick fast from time to time, and on examination I find that they are covered with the crystals of sulphate of copper. Of course, sulphate of copper, I need not say, is the product of the action of sulphuric acid and air upon copper.

In the total estimate of the damage to goods, can you give us any ratio of the proportion of damage by gas? No, I cannot.

Mr. PHILBRICK: A compensation case?

Witness: The damage caused is not merely proportional to the quantity

of sulphur in the gas, but I should say it would be likely to increase at a more rapid rate than the increase in the proportion of sulphur in the gas; but that is a matter of opinion.

Mr. O'HARA: Have you anything to say about the comparative results of burning gas in Liverpool, Manchester, Edinburgh, Glasgow, and London with reference to this sulphur?

Witness: I think that the illuminating power of the gas that is burnt is a very important factor in the case, because, if for the production of a given quantity of light you require to have a large volume of gas, you will get more sulphuric acid produced in your room than if you are burning gas of a higher illuminating power; and, as the gas with which we are supplied in London possesses very low illuminating power as compared to what is supplied to many other towns in the kingdom, I think that is a very important element in the matter, and that it is desirable that the sulphur should be kept down in the London gas to the lowest practicable amount.

In your opinion, as to the use of lime for the purification of gas, if it is attended with proper precautions, should it cause a nuisance in the neighbourhood?—It certainly would not with proper precautions. I have known the process carried out in Manchester, where I lived for six years, and had an opportunity of seeing this process of purification by lime carried out. There was practically no nuisance to be complained of at the gas-works, but there was a nuisance by carting this lime through the streets. It was originally carted away in open carts, and, of course, the lime smelt abominably as it passed through the streets. That was really an unnecessary thing, as it could have been taken in closed carts, and then, of course, there would have been no nuisance of that kind. It was not in consequence of the process at all, it was the careless way of doing it.

Supposing for a moment that it was necessary to devise another process, can you state to the committee how, while still using peroxide of iron, the sulphur might be removed from the gas in a different, and, perhaps, in a more satisfactory manner?—There are several processes which have been proposed from time to time, and one of them, at least, has come into practical use, I believe; but I am not able to speak, from my own observation, as to its success. One of those methods, and the oldest of them, is that known as Bowditch's process, which consists in passing the gas over heated lime, lime heated to about 500° Fahr., and maintained at that temperature. The sulphur compounds which I have been speaking of are, by contact with this hot lime, transformed into sulphuretted hydrogen, which can be then removed by passing over peroxide of iron, and getting rid of sulphuretted hydrogen, that is clear. I mention this method as a process that could be used if it were again found desirable to substitute the peroxide of iron for the lime purification, because then the peroxide of iron would remove the sulphuretted hydrogen caused by the heated lime. The heated lime goes on performing this function for a very long time, it is very long before it gets exhausted, so that there is practically no expense in the lime; the only cost consists in the provision of the plant, and in the maintenance of the lime and gas at the temperature of 500° whilst the action is going on. The quantity of lime is infinitesimal here.

Then, with reference to the plant, you said it was simple plant?—I think so; but I am not an engineer, and I have not seen it erected on a large scale, so that I would rather not say anything about it. That is one of the processes. I said there were three of them. The second process is the invention of Mr. Vernon Harcourt, who substitutes porous materials of various kinds for the lime, and finds that they will, to a certain extent, at least, perform the functions of lime. I have no experience of that process, and have only heard that it can be used in that way.

The substitution of porous substances, such as brickbats, and so on, for lime?—Yes. Then there is a third process, which, I believe, has been extensively used in the Manchester Gas-Works, and that is Mr. Leigh's process of removing sulphur compounds. It consists in washing the gas with sulphuret of ammonium—with the gas liquor, in fact. By bringing the gas in contact with the gas liquor that is collected in the condenser, those sulphur compounds are extracted from it to a considerable extent, and the sulphur is brought down to 10 or 15 grains,

or something like that. There is another process, I believe, by General Scott, which is a modification of the lime process. It is by heating the lime in a different way. It was tried, I may mention, at the South Kensington Museum a year or two ago on a tolerable scale, and was found to answer pretty well.

Dr. Odling was called here yesterday, and he gave the committee some very interesting evidence, and admitted, if I take his evidence correctly, that there was damage from burning gas, but he said it was due to the desiccation of the air, and not to the sulphur in the gas. Did you hear him say so?—No, I was not here yesterday at all, and I have not had an opportunity of reading the evidence.

Dr. Stevenson put in evidence two tables showing results in two rooms, in one of which gas was burnt and the other oil, and I find that practically the desiccation was the same in both cases. The desiccation, therefore, being common to both, we must ascribe the damage which took place in the one and not in the other to the sulphur which was in the gas?—Dr. Stevenson's results show that which I certainly should anticipate would be the case, because in burning oil in oil lamps you produce a much smaller quantity of water for a given amount of light than you do in burning gas; consequently, I should think that the desiccation would be, perhaps, a little greater in the case of oil lamps than in the case of gas. It certainly would be very much greater if you require to develop the same quality of light. But then an oil lamp produces less heat per 100 units of light than a gas lamp; therefore I should anticipate the desiccation would be something nearly the same with oil as with gas, and that is what Dr. Stevenson appears to have got as the result of his experiments. My own experience goes to show that you may burn oil lamps in rooms without any damage of the kind complained of, whereas you cannot burn gas. Bisulphide of carbon, when burnt alone, becomes chiefly sulphurous acid—almost entirely sulphurous acid—and that simply in a room gets converted into sulphuric acid. The conversion of it into sulphuric acid is very much facilitated by a moist atmosphere; but a good deal of the matter in the atmosphere, which is supplied by the gas, the water, and the sulphide of carbon, is burnt in the gas. When burnt in the gas it becomes almost entirely sulphuric acid before it leaves the room, unless the ventilation is very good indeed. I think that is a very objectionable thing.

Mr. PHILBRICK (in cross-examination): You have given us three lime processes, or three processes of purification; I will ask you a question or two about those. First, as to Mr. Bowditch. Do you know that the Bowditch process was put into operation at Wakefield?

Witness: I am not aware that it was put into operation on a large scale. I know that Mr. Bowditch made experiments on what would be the largest scale experimentally there, but I am not aware that it was ever applied to the whole of the Wakefield gas.

Do you know from your own knowledge, not from hearing or from what others have told you, that the Bowditch process has ever been practically used?—I do not know from my own knowledge that it has been practically used on a large scale. I have used it myself for months on a small scale.

Do you know that it was tried at Wakefield, and that it was found impracticable to subject the gas to the heated lime a sufficiently long time to satisfy the exigency of gas-making in a practical way—that that was the objection?—I do not know it, because, as I say, I do not know anything about Wakefield.

Cross-examination continued: I believe that Mr. Vernon Harcourt's process of heating the gas has been put into operation to about the same extent as Mr. Bowditch's; but I may say, with regard to that process, that I know nothing of my own experience; I have not even tried it myself. I know that he invented it, and I have heard him say (and he is a great authority in gas matters) that he has no doubt it could be practically applied. Mr. Leigh is the Medical Officer of Health and Chemist to the Manchester Corporation. The corporation are the owners of the gas-works in that city. I believe they have adopted Mr. Leigh's process; I have not seen it, but I have been told that they have applied the process for several years past; it is not a newly-invented process. I do not know

that they abandoned it in 1875, and have not used it since. I remember hearing of its being tried in the South Metropolitan district. I do not know that it proved an utter failure. General Scott's process is lime heated at a higher temperature, and some other modification also. It has not been adopted, except experimentally, at the South Kensington Museum. My opinion is that all the sulphur compounds which are burnt in gas ultimately resolve themselves into sulphuric acid. I presume we may say that the whole quantity at the point of combustion is, for the moment, in the condition of sulphurous acid. I have made experiments —not in a room, but in a glass vessel—to determine the relative proportions of sulphurous acid and sulphuric acid in the combustion of ordinary gas. There are no known methods by which the relative quantity of sulphurous acid and sulphuric acid can be determined at the very moment in a room with accuracy, but in their passage to the room you can determine. I do not think I have ever determined the presence of sulphuric acid in a room.

Mr PHILBRICK: Not having determined it to be present, why do you say it ultimately assumes the form of sulphuric acid?

Witness: I will tell you exactly. I have received the product of combustion from an ordinary gas-flame in a class cylinder of a particular size, and I have determined the quantity of sulphuric acid and the quantity of sulphurous acid produced under those circumstances, and I have found a certain quantity of sulphurous acid there and a certain quantity of sulphuric acid. Then I have increased the size of the cylinder and repeated the experiment again with the increased size of the cylinder, and there was always a large quantity of sulphuric acid and a smaller quantity of sulphurous acid formed, and as the result of these experiments I concluded that when those products of the combustion of gas are passed into a room instead of into a small glass cylinder, then all the sulphurous acid is converted into sulphuric acid.

First let me ask you, was it a closed cylinder?—No, there was a draught to it, by which the products of combustion passed through the cylinder. There was first a trumpet-shaped tube over the gas-flame, by which the products were conducted into the cylinder, and another tube from the cylinder, by which the unconsumed products escaped into the room.

Was that what is known as the Letheby apparatus?—It was substantially the same as the Letheby apparatus.

Did you find there the sulphuric acid combined or in a free state?—In the free state almost, in the largest cylinder; all the sulphur compounds I found in the water condensing there were in the condition of sulphuric acid; there was not a trace of sulphurous acid.

But the large cylinders were abandoned, were they not, because they were found not to absorb one fifth of the entire quantity?—Certainly not; they absorbed a great deal more than that.

Were they abandoned?—The Letheby process of determining the sulphur and gas was abandoned in favour of the more accurate process invented by the Gas Referees.

Under Dr. Letheby's own advice and opinion, in carrying out his own experiments, was not the large cylinder abandoned in favour of the smaller one, because the smaller one was more accurate?—No; certainly not. In my experience the larger the cylinder the greater the amount of sulphur that is to be obtained in the shape of sulphuric acid from burning gas.

I am quite aware that you have said that the larger the cylinder the more often these products shape themselves into sulphuric acid. You have used that as an argument to show that in a room there would be a still greater proportion of sulphuric acid?—Yes.

Do not you know that Dr. Letheby himself, in conducting his own experiments in his own way, he being the discoverer of these sulphur compounds, actually prohibited the use of these large cylinders because they led to results that could not be trusted?—If he did abandon them it would be because they gave too much sulphur.

You do not mean to say that a man like Dr. Letheby, who has passed away from us—a gentleman of his scientific attainments—would discard an apparatus because it led to a certain result, if he believed that result to

be a true one?—First of all, I do not know that he did abandon the large cylinders; and, in the second place, I know that if he did it is quite contrary to my experience that they ought to be abandoned because they give too little sulphur, because I always found the larger the cylinder the more sulphur you obtained in the shape of sulphuric acid. Just allow me to explain that part of my answer to which you seem to take objection. Dr. Letheby, in proposing this method of testing gas, had in view the use of a particular sized cylinder, and he said, "That is my apparatus, which has such and such dimensions. The gas ought not to contain more than 20 grains of sulphur in 100 cubic feet." Then it was found afterwards, I think by other persons, not by Dr. Letheby, that the larger cylinder produced more sulphuric acid; but Dr. Letheby, I think, altered his evidence before the committee, and said, "It is not fair to use the larger cylinder; the Act of Parliament contemplated the cylinder of the size in which I first invented it;" and that was the reason, I believe, that he abandoned it.

If you have exactly represented the effect of Dr. Letheby's evidence in the reverse sense to that in which he gave it, what would you say about your conclusion?—I cannot alter my conclusion from my own experience.

Then it strikes me that your conclusion is entirely independent of the premises from which you draw it?—No; it is based entirely upon my own experiments, and I cannot give up my own experiments.

Is the free sulphuric acid, which you say you found in these tubes, produced always under the same conditions as they would be by the burning of ordinary gas in an ordinary apartment?—It is as near as possible, in the experiments to which I have referred. The difference is simply that the products are passed into a smaller chamber instead of a large chamber. There was no ammonia put in the chamber. These were experiments with a view of ascertaining how much free acid there was, and there was a considerable quantity—a large proportion.

Cross-examination continued: There is no sulphur test in Manchester. The gas there is of a higher illuminating power than in London. I am not aware that in Manchester the injurious effects attributed to the sulphur compounds are visible all over the city. The quantity of sulphur given off there is reduced to about one-half, by the gas being of double the illuminating power, with the ordinary burners employed. At Manchester I believe they do not use lime, but peroxide of iron in the purification. It is cannel gas supplied there which cannot profitably be burnt in an Argand burner. It is better to employ a fishtail burner. Cannel coal does not contain a greater proportion of sulphur, as a rule, than ordinary coal; at all events, what is really of importance here is this, that the gas manufactured from cannel coal contains less of these objectionable sulphur compounds than gas from ordinary coal, because it comes off at a lower temperature. I do not know, since the tests have been taken in London, that at the stations where cannel gas is made the proportion of sulphur compounds has been invariably greater. I have not seen any room in Manchester where injury has arisen from the sulphuric acid produced by the combustion of gas. I have not lived in Manchester since 1857, and at that time they were purifying with lime. I have seen its corrosive action in my own rooms in London, first at Haverstock Hill, between 1857 and 1860, and then at Lancaster Gate up to the present time. In both cases the gas was supplied by the Imperial Company. I have not noticed the effects in the formation of a zone round the top of the room, but I certainly noticed that these effects were very much stronger nearer the ceiling. The metal articles about the room, or 3 or 4 feet from the floor, were comparatively unacted upon, while any metallic substances near the ceiling were rapidly corroded. I never made any experiments as to where the action began. They were really not experiments, only the result of experience. I found that the brass cranks at Lancaster Gate, from 6 to 12 inches from the ceiling, were very powerfully corroded, and covered with crystals of copper. I cannot tell what wash they had been dipped in by the manufacturer; but whatever it was it had all gone, while the other cranks retained their wash. This was in the pantry—a small room where the ventilation was deficient. I never burn gas in the ordinary rooms of the house; I have given it up now on account of the sulphur compounds and the low illuminating power. It is only burnt in the

basement and in the passages now. There are no damp walls in my pantry, and a damp wall would not produce sulphate of copper. I use paraffin duplex lamps in my dwelling-rooms. There is scarcely a trace of sulphur in paraffin.

Re-examined by Mr. CRIPPS: The quantity of cannel used in making gas in London is only a small per centage; but in Manchester the gas is made entirely of Wigan cannel. If you have a gas of high illuminating power, you do not want so much of it in quantity; and I know from my gas bills that I used much less in Manchester to illuminate my rooms than I did when I used gas in London. I should, therefore, not expect to find so much sulphur compound present.

Mr. CRIPPS: I want to ask you about the inverted tubes that you have spoken of. You say where the tube is contracted the sulphurous acid is generally found, but when you get the larger tube you find sulphuric acid?

Witness: Yes, I found sulphuric acid myself in the very smallest tube, but more in proportion to the size of the chamber—it is not exactly a tube.

If, instead of being a chamber, it was a room, there would be a considerable portion of sulphuric acid there, would there not?—I think that is a fair inference.

Will you tell the committee why that is—you, of course, have a reason to assign why, as the tube widens, the sulphuric acid increases?—The transformation of sulphurous acid into sulphuric acid is a question of time, and the length of time you could allow these products to remain in a close chamber, even of the largest size that can be blown, is, of course, very small, compared to the length of time it would remain in a room; hence the process of transformation will be much more perfect in the room itself than it possibly could be in the largest glass tube that could be used for the experiment.

By the COMMITTEE: It would take a longer time to deposit, and to combine with oxygen it must combine with atmospheric oxygen; that is a process that requires time—say ten minutes or a quarter of an hour—and you must keep up a rapid current of air over the glass to get perfect combustion, and all this air must be carried up in a glass chamber in order to deposit the acid. I should not say that a greater quantity of sulphuric acid would be produced in a small room than in a large one, and with the same amount of gas, I should say, if there is a difference between a large room and a small room, the larger quantity would be produced in the larger room, because there would be still more air. Still, in a room of ordinary dimensions, it would probably not be large enough to transform the greater part of the sulphurous acid into sulphuric acid. The size of the room is almost infinitely greater than the size of the glass chamber under which these experiments were taken.

Mr. CRIPPS: Then, whatever may have been the immediate object of Dr. Letheby's experiments, your experiment in having first the contracted and then the larger tube showed you that sulphur was converted into sulphuric acid, if you gave it time?

Witness: Yes.

You have been asked whether Mr. Bowditch's process has ever been applied or not upon a large scale. Did I not understand you to say that you had tried it yourself?—Yes, I have tried it on a small scale repeatedly, and for a considerable length of time. On one occasion I remember passing the London gas, for a fortnight continuously, through a tube filled with lime, heated to a temperature of 500°, and during the whole of that time the sulphur, in what is called an irremovable form, was continuously and uniformly transformed into sulphuretted hydrogen, all except 4 grains per 100 cubic feet.

Then would that experiment lead you to believe that there is nothing to prevent it being adopted on some larger scale, and with success?—I cannot believe that engineers could not produce a result of that kind. It is so very simple, and the expense of getting the lime at 500° is so small, that it seems to me, therefore, to be no insurmountable difficulty. The only problem would be the applying it on a larger scale. It is a purely engineering question.

The CHAIRMAN: Do you believe that these sulphur compounds have any injurious effect upon the health of human beings?

Witness: I should have considerable doubt as to there being any appreciable effect produced upon persons in ordinary robust health, but for invalids and persons with weak respiratory organs, I think a good deal of suffering, at all events, would be produced. Whether there would be ultimate injury or not I should not like to say, not being a medical man.

Do you think that the difference between 15 grains and 35 grains, which is represented by employing this lime process, would have any appreciable effect upon the health of even an invalid?—I think so. I think the difference between two rooms, one lighted with gas containing only 15 grains, and another lighted with gas containing 35 grains, would be very considerable—in fact, I know it is from having experienced the atmosphere of the two rooms.

Then, perhaps, you are in a delicate state of health yourself, as regards the respiratory organs?—Certainly not; but I feel the effects of the sulphuric acid in the throat. There is a peculiar sensation similar to that which one perceives in a London fog. It is very much the same sort of thing, and it is very much stronger in a room lighted with gas containing the maximum amount of sulphur, as compared with a room in which there is the minimum amount of sulphur.

Then you have no hesitation in referring that to the different amount of sulphur compounds?—It is entirely due to the sulphur compounds.

Is there anything injurious to human health in the process of lime purification besides the disagreeable smell?—I should say decidedly not because of the offensive smell arising from sulphuretted hydrogen or sulphate of ammonia—and these are two reagents that are daily in use in chemical laboratories, and the students working in these laboratories are exposed to them very much more than persons would be to the lime from gas-works, and yet no injury to health results.

There is sulphur to some extent produced in any room where a full fire is being burnt, is there not?—There is sulphur produced in a fire, but it all escapes up the chimney. Unless the chimney smokes, no trace of it comes into the room.

Mr. *Arthur Herbert Church*, examined by Mr. CRIPPS.

I am a Fellow of the Chemical Society, and Professor of Chemistry at the Agricultural College, Cirencester. I have paid a good deal of attention to the compounds produced by the combustion of sulphur in gas. I have found generally that the whole of the sulphur in the gas may be converted into sulphuric acid when the quantity of sulphur is small; but when the quantity of sulphur is large, say over 30 to 35 grains in 100 cubic feet, a small portion of it, when the combustion is as perfect as you can get it, is still in the state of sulphurous acid; it does not go further; it does not get completely oxidized. But under the ordinary conditions of combustion, especially when a small quantity of gas is burned, and where there is an ample supply of air, the sulphuric acid is the only product of the combustion. I have had, from time to time, a number of specimens sent to me of leather binding from the upper shelves of libraries, chiefly private, but on some occasions public, and I have been asked to determine the cause why they were reduced, as one of my correspondents said, to the condition of Scotch snuff. I attributed it to the presence of sulphates in larger quantities than in natural dressed leather; that is, in leather that had been submitted to the process of dyeing, or something of the same sort. I also found that the watery extract showed a distinct acid reaction, due to the presence of free sulphuric acid. I attribute the presence of large quantities of sulphate in that disintegrated binding of books from upper shelves to combined sulphuric acid as well as free; to the action of the free produced by the burning of the gas on lime, and which prevented the whole of it being in a free state. The sulphuric acid, by its action upon the leather, combined with the lime, and formed sulphate of lime. I found a very large quantity of combined sulphuric acid, and a small quantity of sulphurous acid in the injured bindings. In completing this account, I ought to say, with reference to metals, that I have found crystals of sulphate of copper and sulphate of zinc, both due to the action of sulphuric

acid on the copper and the zinc. They could only have been formed by the action of the free sulphuric acid produced in the burning of the gas upon the metals.

Mr. CRIPPS: You mentioned the effect upon leather. Are there any other articles upon which this effect could be observed, such things as fibre, and textures of different kinds—dresses, muslins, or the canvas of pictures; would it have any effect upon those?

Witness: My experiments have almost entirely related to the canvas of pictures, which have been found to become rotten when hung at a great height, and I have found more sulphates, and in a few cases free sulphate, from the watery extract of disintegrated canvas, which has been hung high up, while pictures that have been hung lower than 12 or 14 feet have been comparatively free from sulphate when removed from the same room.

Would it have any effect upon the oil and varnish of pictures themselves?—I found that some varnish resists the action of sulphate almost completely, but lac and shellac and mastic are rendered brittle, or the process of becoming brittle is accelerated—they do generally become brittle, but more quickly brittle when they are hung high up in a region which is hot, and laden with a larger quantity of sulphuric acid than the air of the room below.

Are there other materials on which it would have that effect—such as white lead?—I find white lead partially converted, in the upper walls of a room, into sulphate of lead, the walls injured, and the texture disintegrated, while the lead paint in the lower part was not in any way affected by the gas, or only to a very slight extent.

Its effects upon some other matters are well known to all of us, probably upon copper and brass metals; have you observed its effects upon those?—I have a copper vessel in my laboratory which has been heated with a paraffin lamp, and another similar one which has been heated for a like time at intervals for a similar purpose with gas-burners, and drops of strong solution of sulphate of copper are formed every morning on the one which has been heated by the gas-burner, while the other shows no appreciable corrosion except a small darkening of the surface, which is due to the action of the copper. This was at Cirencester, and out of the province of the metropolitan gas companies; consequently we have a very impure gas. I am not prepared to say what its general average of purity is.

Would it have any effect upon statuary and marble even in a museum?—I found it slightly rotted the surface of finely-polished statuary marble which had come from the hand of the sculptor; it was found to be slightly corroded, and I found that you could wash off sulphate of lime or gypsum, the same as often occurs in London upon the marble from sulphur that is burnt in coal. It is well known that you can extract from the stone of some parts of Westminster Abbey portions of sulphate of lime. I know as a fact that some of the best sculptors in England have what is called skin disease, and are undoubtedly affected by something. This may be partly due to the effect of sulphuric acid, and partly to other influences.

Under these circumstances, do you think that it would be desirable that means should be employed to take out these sulphur compounds from the gas which is to be in use generally in London?—I think so, upon the score of the preservation of the materials and objects, both useful and decorative, in our houses.

Cross-examined by Mr. PHILBRICK: I am not prepared to say that I would have all gas absolutely free from sulphur. What the restriction should be is a question I feel myself unable to answer. I would restrict it as far as it could possibly be done. I have not had my attention called to the limits prescribed in London by the Referees. I do not know that in the case of the Commercial Company it is 30 grains at the present moment. I am not prepared to speak authoritatively on the point as to how much sulphur there would be in the gas, supposing it was purified by the oxide of iron process. I have made one or two determinations from time to time of the sulphur contained in the gas at Cirencester, to see how much sulphide of carbon there was in it, solely for the purpose of attempting to purify the gas for my own use. I found a proportion which corre-

sponds to about 35 to 40 grains of sulphur in 100 cubic feet, and in one case in which they did not take out the sulphuretted hydrogen, I found about 70 or 75 grains. Estimating the quantity at 35 grains, that would produce about 90 or 100 grains of sulphuric acid, or three times its weight. I have not made a calculation as to volume.

Mr. PHILBRICK: You have referred to some leather books, and so forth—some binding that had perished. Those bindings, I suppose, had been treated with size. You know there is acid in size, do you not?

Witness: There is, sometimes; but I made all my experiments of comparison with the leather which had been taken from a lower shelf of the same library.

Then it is just possible, unless you had the same identical binding in each, and leather treated in the same way and bound by the same man, that you might have size in the one case and not in the other?—Yes; still it would be very singular if all the leather on the top shelves contained the sulphuric acid. I do not know where those books were bound which came from the top shelf and which from the bottom. I have taken some myself from where gas was burning in the library at Cirencester.

In the library at Cirencester, where gas was burning, was the condition of the injured books which you have described the same generally in all the upper shelves?—It was the case with those books which were not frequently moved in the upper shelves—the two upper shelves. They suffered most, and those down near the floor but very little.

Have you ever read the late Professor Faraday's evidence on this subject in the inquiry as to the Athenæum, and Professor Brand's?—In past time I have, but I have very little recollection of it now.

Cross-examination continued: I have not read Mr. Vernon Harcourt's researches upon this matter. I am aware that the atmosphere of all large towns contains more than a trace of sulphuric acid; but I am not aware that the top shelves of a library have a peculiar attraction for this impurity. I should not attribute any portion of the sulphuric acid in the atmosphere out of doors to the presence of sulphur in gas. I cannot say generally that the bindings of books suffer more from decay on the upper than on the lower shelves of a library, except where I have found gas to be burnt. Decay has never been brought to my attention in other cases. I cannot be quite sure whether I have had any experience except where gas has been burnt, because I have not had my attention drawn to it lately. I have had experience upon that fact sufficient to enable me to answer on oath, and give the committee a reliable opinion. Whatever investigations I have made have been made with reference to the presence of sulphuric acid in bindings. I hope I am chemist enough to know that in the pigments used by painters there is an acid present. In some there is chromic acid, in some carbonic, and in some acetic acid. I am aware that the mastic and other varnishes used by some painters for glazing and for the transparent tones of pictures do, apart from the use of gas lighting altogether, decay of themselves. I am not prepared to admit that they have therefore been abandoned, and that the reason why the tints of Sir Joshua Reynolds and other great masters fly, is because of the bad medium they used. I know it is the greatest reproach to an artist if he uses any amalgam or medium of that sort, as they do not stand. The megylp which used to be met with, which is half copal and half mastic varnish, is now, to a great extent, discarded by everybody who understands it. The ultramarine, which is used for the skies of pictures contains sulphur, and it has been found that where used the canvas has perished behind it.

Re-examined by Mr. CRIPPS: There are many materials used in painting and matters of that kind in which you can trace the effects of sulphuric acid. That is one of the strongest decomponents we have, and would leave its effect upon anything that could be decomposed in that way. I have, for the purpose of experiment as to the effects of sulphuric acid, compared the bindings of books on the higher shelves of libraries with those on the lower shelves in rooms where gas has been burnt, all other circumstances being, as far as I know, the same, and in those on the upper shelves I have found sulphuric acid.

By the COMMITTEE: I have been making these observations for about ten or fourteen years. I have a work upon the subject in preparation, and have been obliged to make experiments upon artistic materials for that purpose.

In those volumes which were sent to you, were they sent at your request with a view to your work?—A good many of those to which I have referred—and they all gave me the same result—were sent to me as a professed chemist to advise as to what was the cause of the destruction of the binding, and how far I could suggest a remedy, and I have always suggested complete ventilation.

I think you said that the more air the greater quantity of sulphuric acid would be formed?—Only that the more complete would be the product of sulphuric acid in the burning of the gas at first. It would all ultimately turn into sulphuric acid, therefore its effects would be the same, only that at the moment of preparation, before the burning is complete, you do not get it so completely formed.

Then the injury to the upper shelves of the bookcase would be caused, not by the sulphuric acid which was created at the moment of combustion, but from the sulphurous compound which afterwards turned into sulphuric acid?—Partly by the one and partly by the other.

Therefore you say the better ventilated the room is the greater the proportion of what would ultimately become sulphuric acid, and that would be produced at the moment of combustion?—Yes; and it would be carried away in a well ventilated room before it had time to do injury to the books. May I be permitted to say it was only portions of bindings from volumes that were sent to me, as a rule—only pieces of leather.

But the binding of the volumes—were you informed, when they were sent to you, whether they came from the upper shelves or the lower shelves of the library? Was your attention called to that fact?—In some cases it was; in some it was left for me to find out.

How did you ascertain that you were right in your supposition?—They were labelled. Those which I reported upon as containing sulphuric acid I was afterwards told were taken from the upper shelves. In some instances I never heard the result; I was merely asked my opinion without reference to where the book came from, or anything about it.

THURSDAY, MAY 3.

Professor *Frederick Settle Barff*, examined by Mr. CRIPPS.

I am Professor of Chemistry to the Royal Academy of Arts, and I have made it my business to examine into the causes which have an injurious influence upon pictures. I have found in those investigations that the products of the combustion of coal gas are injurious to them—as far as I can trace it to them; and I think I can. In London, where gas is purified from sulphuretted hydrogen, I do not find that the blacking of the white lead goes on as in places where that purification has not taken place. If, however, that happens, it is a matter which can be remedied. By washing the defective picture with peroxide of hydrogen I can restore the colour, if it is not too far gone.

Mr. CRIPPS: Now what have you found to be the effect of the combustion of the sulphur in the London gas?

Witness: Sulphurous acid gas is formed by the combustion. That sulphurous acid gas comes in contact with the moisture in the air, and gets oxidized very very rapidly, and becomes sulphuric acid; and the sulphuric acid is not a volatile thing which will go away like sulphurous acid, but it mixes along with the moisture of the room, and deposits upon the cold parts of the room, as moisture does that is usually upon the walls. If it gets upon the walls, it will get on the pictures; and if it gets on the pictures, it has, in my opinion, this effect. First of all upon water colours. Ultramarine is a colour which is affected, and is perfectly destroyed by moderately strong sulphuric acid, and is gradually destroyed with excessively dilute sulphuric acid; therefore, if it comes in contact with the ultramarine, it simply destroys the colour perfectly, though slowly. After a time it will act upon zinc oxide. Now zinc oxide, or zinc white as it is

called, is a thing which is generally used as a pigment among artists at the present time; and the action, if a picture is unprotected, is to convert a portion of the zinc oxide, which is opaque, into zinc sulphate, which is a tolerably crystalline substance; and this substance I have found upon the paintings of several artists, I think Mr. Frith's, with several others I do not remember. As I was called here to-day without the slightest warning, I only got the information early this morning, and I have not been able to verify the names. Therefore I must say I *think*; but in several of the paintings, where the zinc white has cystallized and become soluble it can be seen by the microscope. This, of course, interfered with the opacity of the picture, and therefore destroyed its effect, besides making it spotty. I attribute that to the presence of sulphuric acid.

By the COMMITTEE: Mr. Frith wrote to me, when I was staying at Cromer, in the summer of last year, as to a picture, and I wrote to him to that effect. It is an opinion which I formed and expressed quite independently of the present inquiry.

Mr. CRIPPS: With reference to canvas also, on which so many pictures are painted, what do you say as to the effect upon canvas?

Witness: I have a difficulty in getting a picture to experiment upon, but I have taken a piece of canvas and exposed it to the action of excessively dilute sulphuric acid for a long time, and this I have shown in my lectures for the last six years at the Royal Academy, and I have shown the students that by keeping this stretched and tapping it, you will be able to knock the canvas through, and a portion of it will come away in dust, quite rotten. I attribute that to sulphuric acid mainly. We know in our laboratory that sulphuric acid does do this. It rots our cloths perfectly. If a picture be covered with mastic varnish, I know from experiment that dilute sulphuric acid is injurious. Mastic varnish is a varnish which takes up moisture, and gives a sort of bloom to the picture which artists do not at all like; and that bloom is owing to the hygroscopic character of the mastic varnish. Then, if sulphuric acid is in the room, and I think there can be no doubt that it is, and if it cannot get out of the room, and if it is not carried away by the draughts, it must settle somewhere, and it must, among other places, settle upon this mastic varnish; and if it does settle upon it, the effect is to corrode its surface, and take away the bloom; and if the surface be corroded, the picture readily gets dirty, and has to be varnished again. I have made experiments upon a bad painting, done on purpose for experimenting upon, to see what the effect of this might be upon it. The result has been to destroy the ultramarine slowly, and to interfere materially with the zinc white. I cannot say anything as to the other colours, except the iron colours; I think they have been damaged by it, for they, being oxides of iron, would be dissolved up in part by the dilute sulphuric acid, and would therefore be injured, and I think I have noticed traces of injury on the oxides of iron.

Have you, in consequence of the state of the pictures that are in your own drawing-room, been led to give up the use of gas for those reasons?—Yes; since I have bought valuable pictures I have had a gas-burner made with the pipe going into the flue, and another pipe coming from the outside, so that the whole of the particles of combustion are carried away. In my drawing-room I have given gas up altogether, and use nothing but lamps. I found that injurious effects were produced from the gas in the room before it was done away with. Nearly all the friends I have who come notice the difference between the sensation of spending an evening in the room now to that which they felt when they spent an evening in the room before. I have now two 22-candle Silber Argand burners, and before I had only two 3-light bat's-wing burners.

In your lectures at the Royal Academy have you proved the production of those products in the combustion of gas?—Yes. I pass the products of combustion from coal gas, developed by means of an apparatus, through baryta water. I then dissolve up the white precipitate, which is mainly carbonate, in hydrochloric acid. I then have a sulphite of baryta in solution, and I add that to the chlorine water, which oxydizes the sulphite into sulphate, and throws it down as a white insoluble precipitate, and in this way I have determined approximately the quantity of sulphur burnt in the gas from the sulphide of carbon.

I believe that you generally advise artists to give up the use of gas in their studios?—Every one; all the members of the Royal Academy I have advised to do so, and all the students who have applied to me I have advised to give it up, or else to use the arrangement which I have—which is an adaptation of the one that existed before—to carry off the products of combustion.

Is the reason that you give that advice because you think that the sulphuric acid from the sulphur compounds which you detected is injurious?—Certainly, and for no other reasons; because there is no sulphuretted hydrogen in the London gas.

Cross-examined by Mr. PHILBRICK: My judgment is that the combustion of gas, unless under favourable circumstances, is always, more or less, attended with injury to pictures, because there is an amount of bisulphide of carbon in it. I have never tested the difference between 15 or 16 and 40 grains per 100 cubic feet of sulphide of carbon. The ventilating apparatus in my house is a very costly thing; it is not within the reach of many people. The whole apparatus cost me about £45. In the national collections gas is very rarely burned. It is burned at the Royal Academy, but there it is all in sunlights. The ventilation there is not very efficient. I think there are no injurious results produced upon the works of art in the room; at least I am not competent to speak about that, because I have never been referred to, nor been shown any of the pictures.

Mr. PHILBRICK: Then I may take it that, with regard to the national collections, and matters that come officially under you, there has been no complaint of damage from that?

Witness: But I have no official connexion with the national collections. I have nothing to do with the National Gallery; it is only with the Royal Academy.

I do not know whether you are aware that the lighting of the Vernon collection of pictures was fully considered by a committee of scientific men?—Yes, I am.

Was the result of that that gas illumination was adopted?—That I am not prepared to say. I do not know how it is lighted. I confine my attention to my own work at the Royal Academy. I cannot speak to any of the national collections at all.

Cross-examination continued: If you treat with diluted sulphuric acid the pigments ultramarine and zinc white and the compounds that have an iron basis, you may destroy them more or less. You may also in that way destroy the fibre of hemp. Mastic varnish practically requires to be renewed very often. The only thing is that artists put it off because they do not like sending their pictures to varnishers, and they do complain that I have introduced at the Royal Academy a new system of varnishing to get rid of that. An artist does not even like to varnish his picture himself until it has stood for some years for the oil to get hard. Mastic varnish is almost invariably used, because there is no other. They cannot very well use copal; it is a bad varnish for pictures, as it has a habit of dragging the colours underneath if they are not sufficiently hard. You may have seen in art galleries a number of pictures cracked; that is mainly owing to the fact of the varnish being used in too large quantities on a colour which is not sufficiently hardened. To prevent that, mastic is usually had recourse to as being more elastic. I do not know whether pictures in country towns, where gas is not subject to the same conditions which prevail in London, suffer more from the effect of sulphur compounds than pictures exposed to London gas. I do not know whether pictures that are hung high up on walls suffer more than those on the level of the dado. When pictures are sent to me for examination they are always placed on the level, and I cannot tell where they may have been. I have never noticed whether the gilding of the frames of pictures has been differently affected according to the positions in which they have been hung. I should prefer to hang them on the dado than above it. No doubt the heat itself in the upper part of a room will produce some of the injuries I have mentioned; it will injure the varnish.

Mr. PHILBRICK: You would say if there were the presence of sulphur or sulphuric acid, that, of course, would aggravate it, though the heat would bring it up?

Witness: If it is not troubling you too much, I should like to say a word upon that. In the varnish of a picture you have got different media—you have got one substance that contracts at one temperature, and another substance that contracts at another temperature, a little lower, probably. Those varnishes are not good conductors of heat, and the consequence is that when the varnish gets hot it expands, and is by the heat itself driven through to the canvas below it, and consequently it has a tendency to crack; and I believe that the dry heat in the upper part of the room has a very great effect in producing cracks in pictures, owing to the unequal expansion and contraction of the two materials—the layer of varnish and the layer of paint.

That dry heat, of course, to produce sulphuric acid and sulphur compounds, if sulphurous acid is present, requires moisture?—Exactly so; certainly. Of course, if you had no moisture in the room you would have no sulphuric acid formed, for the sulphurous acid will not oxidize at a high temperature.

That explains what somebody said yesterday, that where there was a drier heat the sulphurous acid has not become sulphuric?—No; but in a room where this is continually going on, at the same time that you have moisture of water, or water vapour, in the room to a large extent, that gets deposited on the walls, and I think the point that should be recollected is that sulphuric acid when once formed remains there and accumulates.

Re-examined by Mr. CRIPPS: The heat alone of a dry atmosphere may do some mischief to the pictures. What I am speaking of is the further injury that I attribute to the action of the combustion of gas. I put the two things on two different footings altogether, one being a matter which probably cannot be prevented—the heat in the room—and the other a matter that, if it can be prevented, I think ought to be prevented. If the varnish cracks on a picture, of course the paint underneath gets exposed, and is much more likely to be acted upon by deleterious influences in the air. I have never been at South Kensington Museum in the evening when it was lighted up. I have been there at two *conversaziones*, but I have never seen the pictures lighted.

Mr. *William Charles Young*, examined by Mr. CRIPPS.

I am a Fellow of the Chemical Society, and have been analyst for the Poplar District, and a gas examiner at the Beckton testing-station for the last five years for the Metropolitan Board of Works. For the last nine years I have been almost daily engaged in testing gas to examine its purity and illuminating power. For the last three years I have occasionally made experiments to determine whether the sulphur in the gas when burnt is converted into sulphuric acid or sulphurous acid; and the result of my experiments has been to convince me that practically the whole of the sulphur is converted into sulphuric acid, and not into sulphurous only. I attribute very much of the injury caused to furniture and to bookbindings, and, in fact, anything which is said to be injured by the gas, to the sulphuric acid that is produced by combustion of the sulphur. I have noticed, where gas has been burning, that brass fittings in rooms have become coated with sulphate of copper; that zinc has become coated with sulphate of zinc; and this could only be after the sulphur had been converted into sulphuric acid. I have noticed that the surface of painted walls and furniture is distinctly acid, and that the acid is sulphuric acid. I have also noticed as to dust collected in rooms where gas has been continually burnt, and no fire has been lit, that the dust was distinctly acid, and that the acid is sulphuric acid; and I have estimated the acid as sulphuric acid from dust taken from the top of a wardrobe cupboard in a bed-room where gas only has been burnt. The acid found there was equal to ·335; that is rather more than three-tenths of a grain of sulphuric acid per square foot of cupboard. Taking the four walls only, and supposing it to be evenly distributed over the walls of the room, I calculated that it would be equal to two grains of sulphur, in every 100 cubic feet of gas, deposited as sulphuric acid. Supposing that which I found was upon every square foot of surface forming the four walls, I should have got sufficient sulphuric acid to indicate that two grains of the total sulphur in the gas burnt was converted into

sulphuric acid and deposited upon the walls. The dust which I experimented upon had remained undisturbed upon the shelf for six months, and I calculated there would be rather more than 2000 cubic feet of gas burnt in that time. I cut a piece of the top of the canopy from the top of the bed-hangings, which had been there six months, and I estimated the acid in it as sulphuric acid, and I found nearly half a grain of sulphuric acid per square foot. That, if calculated for the same amount of surface in the same way, would indicate that three grains of sulphur had been deposited per 100 cubic feet of gas burnt; and I think that that is more accurate than the other experiment, because, in the first place, the sulphuric acid absorbed by the wood upon which the dust had collected was not taken into account—the dust was merely swept off the surface of the wood; but in this second experiment, the whole of the sulphuric acid was taken into account, the sulphuric acid that was absorbed by the fabric as well as in the dust lying upon the fabric. A considerable quantity might be taken up by the carbonate of lime in the ceiling in the other case. If the amount could be ascertained that was taken up by the ceiling and of that which was removed from the room by ventilation, I have no doubt that the whole of the sulphur could be accounted for as sulphuric acid in all the gas that had been burnt. I also tested for sulphuric acid upon some advertisement cards that had been exposed in a shop for some time.

Mr. COURTNEY: Before you go away from the room you spoke of, do you happen to know whether the gas supplied in that room was supplied under the 20 grain regulation, or under any regulation?

Witness: No, I believe there is no restriction—the gas was supplied from the Silvertown works of The Gaslight and Coke Company; and I think there is no restriction there as to sulphur impurities.

Mr. PHILBRICK: That is not so.

Mr. CRIPPS: It will be sufficient to let me know where it came from?

Witness: I was under that impression. I know that it is not tested—the gas came from the Silvertown works of The Gaslight and Coke Company.

Mr. COURTNEY: What leads you to say that it was not tested?

Witness: I live in the district, and I know that there is no official tester. It is not tested for the West Ham Local Board nor for the Metropolitan Board of Works.

Mr. CRIPPS: I am informed, I am not sure how it will turn out, that the gas comes from a part of the Chartered district which is not within the metropolitan area, and, therefore, not under the ordinary provisions which the rest of the Chartered gas is under.

The CHAIRMAN: Perhaps it would be well for you to give some evidence upon that point by-and-by, as we have identified the place now.

Mr. PHILBRICK: I can give you evidence upon it.

Examination continued: One of the cards upon which I experimented was a large one, which had been exposed in the shop for six months, and I found as much as 1·8—*i.e.*, nearly 2 grains of sulphuric acid upon the whole surface of it, which was about 3 square feet. I calculated the quantity of sulphur that would be deposited as sulphuric acid upon a square foot of surface, and I found that the tenth of a grain would have been deposited from 1000 cubic feet. I obtained a smaller card from another shop, and estimated the acidity upon it, and found it exactly the same, calculating for the same amount of surface as the larger one. I also calculated the acid which was deposited upon the top of an iron box, which had been exposed for some time in another place. I sponged the surface of the top, which was about one square foot, and I estimated the acidity in the liquid. I found the total acid was nearly equal to 2 grains of sulphuric acid. I have further suspended moistened bibulous paper in a room, and have found that two-tenths of a grain of sulphuric acid was deposited on a square foot from 100 cubic feet of gas consumed. I suspended some moistened linen and some moistened flannel in the same room, and obtained precisely the same results. I tried ventilating the room through a hole in the wall, close to the ceiling, so as to create an outward draught, and hung moistened paper in front of the opening, when I found that the sulphuric acid increased very considerably. In all these

experiments I know of no other source from which the sulphuric acid could be derived except from the gas which was burning there. There was no coal fire burning—nothing but the gas. I have had my attention called to books that have been on the upper shelves of a large library; and I have noticed that they have been abraded upon the surface, and that they are all distinctly acid—very acid—not merely *distinctly* acid, but *very* acid; and I have noticed also that the ridges of the books which project take up more acid than the other parts of the books. I observed it still more with Morocco leather or Russia leather than with ordinary leather. The injury that is complained of is the rotting of the leather of the edges of the covers of a book, so that when the book is opened they crack and break off. The Morocco and Russia leather appear to suffer more, probably on account of the openness of the grain, which absorbs more readily. I sponged the backs of eight volumes —eight octavo volumes, I think they were—and I found a total of two grains of sulphuric acid, of which 1·4—that is, rather less than a grain and a half —was in a free state as free sulphuric acid. Not all the leather, only a part of it had been abraded—the roughened part, that is the edges, was very acid, and is still very acid, although it has been sponged five or six times —a sponge drawn over the surface, not allowed to remain on the book; and that acid is still due to sulphuric acid, and not to any other acid. I have noticed that dust collected in places where much gas is burnt is very hygroscopic; and, moreover, when it is washed and dried it presents all the appearances of charred organic matter—it looks as much like powdered charcoal as anything—in fact, it presents all the appearance of organic matter having been subjected to the action of strong sulphuric acid. I will mention some experiments that I made three years ago, to show that sulphuric acid was formed by combustion of the sulphur in gas, even when the sulphur was there in very large quantity. These are published in the *Analyst* for Oct. 31, 1876. I shall only quote two experiments which I made upon gas which was previously charged with bisulphide of carbon; it was charged by passing the gas over a solution of bisulphide of carbon in olive oil, and the gas was burned very slowly. I think I need not say how the experiment was made; but the result was that the gas showed a degree of sulphur amounting to 444 grains per 100 cubic feet, of which 422, or 95 per cent., had been converted into sulphuric acid. Another experiment was made upon gas containing a still greater amount of bisulphide of carbon; and the total sulphur was 1644 grains per 100 cubic feet, of which 1260, or 76·7 per cent., was converted into sulphuric acid. The object of this experiment was to show that the sulphur compounds are, in fact, converted into sulphuric acid. I may mention that I have collected dust from places where no gas has been burnt, and have invariably found that it was not acid.

Cross-examined by Mr. PHILBRICK: I tested the dust that I last mentioned for the presence of sulphuric acid in precisely the same way that I tested the dust in the room where gas had been burnt. I am not aware of the series of experiments made by Professor Redwood on this point. I cannot call to mind any experiments conducted by chemists of reputation. I supposed that no other chemist had experimented in that direction. For the purpose of determining the quantity of free sulphuric acid present, the absorbent I used was in some cases carbonate of soda, in some cases bicarbonate, and in others caustic soda. It is not necessary that to turn sulphurous into sulphuric acid you must use soda alkalies; there are other things that will do it. If you have sulphurous acid and want to see what quantity of sulphuric acid you can get, it is part of the process to treat it with an alkali; but it is not a part of the process which is designed and adopted for securing the greatest result in the shape of sulphuric acid that the product can yield. I used it to absorb the products of the combustion of the gas. There were no other means of doing it except I used another alkali. You cannot always get sulphuric acid when you have sulphurous acid if you treat it with an alkali. In this experiment I proved that it was not so. An alkali will absorb sulphurous acid, but not convert it into sulphuric acid. It is driven off as sulphurous acid, the sulphuric acid only remaining. It is absorbed by the alkali, and then that which remains is estimated as sulphuric acid. The bed-room hangings from which I extracted

the acid were old ones which had been washed five or six times by an ordinary laundress, and starched in the usual way. I have reason to believe that laundresses do use such things as bleaching powder. I did not inquire whether that was the practice of the laundress in question. The shop from which I obtained the show-cards referred to was a druggist's, in which there was a gas-burner in the window, and one or two others inside. One of the cards had an enamelled surface, the other was ordinary cardboard.

Mr. PHILBRICK: Does it occur to your mind that in the preparation of an enamelled card possibly there is a little source of error introduced that ought to be eliminated?

Witness: I know that in this case the enamel on the card was quite neutral; it was not at all acid. I had another card of the same kind sent to me, and that was quite neutral—not at all acid. There was the ordinary stock of a druggist in the shop—sulphur, no doubt.

Mr. PHILBRICK: You must not put it all upon the gas.

Witness: I give you the facts as I observed them.

Mr. PHILBRICK: Do you put it all upon the gas, then?

Witness: Most decidedly.

Cross-examination continued: The gas was supplied to that shop from the West Ham works, which are not within the London limits. I test the gas at Beckton. My results and those made by the company sometimes agree. At one time I had to complain of the way in which they were conducting their tests, as they were constantly bringing their results in opposition to mine. In the calculation I made as to the quantity of sulphur that was in the dust on the top of the cupboard, I reckoned that the same quantity would be deposited in every square foot of vertical space in the room as that which fell upon the horizontal surface. I did not take into calculation the ceiling at all, nor the floor. I only took the four walls. For the purpose of calculation, I estimated that there would be the same quantity of sulphur on every square foot; I do not say that it is so. As one of the gas testers, I have not formed any idea of what amount of sulphur should be allowed in the gas. In the burning of gas, I have observed a detrimental effect upon things higher up in the room. I attribute that to the sulphuric acid; I do not say that none of it is attributable to the heat, but I know the effect of the acid more than I know of the effect of the heat.

Mr. CRIPPS (in re-examination): I want you just to explain further about this question of the four vertical walls and the cupboard. Why is it that you took the vertical space round the wall as estimating quantity for calculation?

Witness: I took it so as to make it more intelligible to those who were hearing me. I cannot tell at all how much was absorbed by the ceiling. I might have taken the surface of the floor, but it escaped me at the time; and I did not think much sulphur would be deposited on the floor, because that part of the room is better ventilated than the other part, and, moreover, it gets swept and cleaned. My intention was to give the amount of acid, so far as I knew, that was actually deposited on the four walls in the room.

By the COMMITTEE: Was this shop, in which you found the cards, supplied from the same works as the room was in which you made the experiments?

Witness: No; it was the same district, but two different works—one was supplied from the Silvertown works. I cannot say positively whether those works are under restrictions or not.

Mr. CRIPPS: No, they are not; they are some old works which were acquired by the Chartered Company, and when they were amalgamated, the company taking them over kept up the same regulations as to that part of the works as the other company had done before; but they do not come under the regulations.

Mr. PHILBRICK: They are under the Gas-Works Clauses Act of 1847.

The CHAIRMAN: You took no means of testing the gas in the ordinary sense, in either of those places, did you?

Witness: No, I did not.

Mr. PHILBRICK: There is one question that I forgot to ask—namely,

whether the dust was from the upper part of the room? I rather inferred that; but how high up was the dust?

Witness: It would be about 2 feet from the ceiling, and I should think 7 feet 6 inches or 8 feet from the floor.

Mr. PHILBRICK: The Silvertown works are part of the undertaking which was acquired by The Gaslight and Coke Company, and the manufacture is conducted by them in the same way entirely as for the Metropolis at Beckton—it is part of their general supply.

The CHAIRMAN: What I want to know is, are they subject to the Referees?

Mr. PHILBRICK: No, they are not.

The CHAIRMAN: Therefore, they make gas in any way they please?

Mr. *Matthew Hill Loam*, examined by Mr. CRIPPS.

I have been connected for nearly 26 years with the Nottingham Gaslight and Coke Company. For some time I held the position of resident engineer under Mr. Hawksley, he being engineer-in-chief to the company at that time. The works have now been transferred to the Corporation of Nottingham, and I remain as assistant engineer. The works are very considerable, very large; their area of supply being very nearly 150 square miles. In 1851 the largest daily consumption during the winter was 400,000 cubic feet. Last winter it amounted to four millions and a third. The gas supplied has always been of very high illuminating power, and of good quality. Since the transfer of the undertaking to the corporation, great care has been taken to maintain that quality and purity. The gas is tested in the usual way; the illuminating power is ascertained by a Bunsen photometer. With the old 15-inch Argand burner we get 17½ candles. We have never adopted the London burner yet. During the last six months, the average of the sulphur compounds has been 12·65 grains per 100 cubic feet. We purify chiefly with lime, using the oxide of iron in the catch purifier.

Mr. CRIPPS: Now, using lime, and arriving at that amount of purity by it, how do you manage in removing the foul lime from your purifiers?

Witness: The purifiers are cleaned out as rapidly as possible, and the refuse lime is removed to a place of deposit, and covered over with cold refuse lime, the lime which has been already used, and which has gone cold. The nuisance from the foul lime is really not perceptible; it is not discovered beyond the precincts of the works, or very rarely so indeed. The Nottingham works are within the town; the largest of our works are about two and a half miles from the town, and we have another small works at about a mile and a half from the town.

Is there a considerable population round your works?—Oh, yes; the chief population is within the area of the works.

Can you tell the committee a little how you use this spent lime after it comes out of the purifiers?—The cold lime is simply thrown over the warm lime taken out of the purifiers. That is a simple process, and we have occasionally covered the lime over with tarpauling.

You have not experienced any difficulty?—We have experienced no difficulty whatever. At the Nottingham works we are really surrounded by the largest population, and we have never had a complaint to my knowledge.

What becomes of this refuse lime ultimately?—It is sold to the agriculturists, and some is loaded on railway trucks and taken clean away. It is allowed to cool in the trucks, and it is delivered a great many miles away—some 30, 40, and 50 miles, and so on. The other part is kept until it is sold. Some is removed in carts, by the farmers in the neighbourhood.

I am told that you keep a sort of depôt there, and that the farmers can come with their carts and carry off what they like with their carts?—Yes, that which is not loaded into the railway trucks is put into a place of deposit, and the persons requiring the spent lime cart it away. Even in that way we have no complaint of a nuisance.

Cross-examined by Mr. PHILBRICK: I have been in the neighbourhood of the Crystal Palace. I do not think I should like to establish a depôt for foul lime near the Palace if the works were small. In Nottingham the difficulty has been not so much with the gas as with the sewage. The

object of covering the foul lime with tarpauling, or spreading over it some lime which has become innocuous or comparatively so, is to prevent the nuisance of the smell. If we did not take such means we should expect complaints. We carbonize Yorkshire and Derbyshire coal. They are rich in sulphur compounds—one contains more than the other. I have never tested the quantity of sulphur in our crude gas, and cannot give any idea about it. A series of experiments were made some years ago by Dr. Lethbey, Dr. Pole, and others, but I do not remember the results. We are under no restriction in reference to these compounds. We remove them, from our desire to supply a good article. Our gas is better than that of London, and we charge 3s. and 2s. 10d. per 1000. Before the advance in the price of coal we charged 2s. 8d. I have never smelt the foul lime at 200 or 300 yards from our works. We discharge our purifiers about once a day in the winter time.

Re-examined by Mr. CRIPPS: We use lime upon the old plan of purifying, and in that way keep the sulphur down to 12 grains. The lime comes out as carbonate of lime

The CHAIRMAN: You said, as regards the Crystal Palace works, that you thought your plan would not be so well adapted for such small works. What do you mean?

Witness: Of course, if the space is very limited, in changing the purifiers the smell would be discovered much sooner than if you have a larger area to deposit the stuff on in the centre of your works, or in the most remote part; that was what I meant. Of course, every gas company would put the lime where it would be removed farthest away from the public; but if the works are small, of course, it does not give them much option.

There is no doubt, I suppose, according to your view, that as to the Crystal Palace Company, your plan, if adopted, would mitigate very much the nuisance?—I believe it would; I fancy they could do it just equally well as we do.

It is only a question of space, which means expense?—Yes, of course; but I should not think it would mean expense to a very great extent in the neighbourhood of the Crystal Palace.

In working your process, do you find the workmen who have to clean out these purifiers suffer in their hands or eyes?—Not materially; we wash out all the purifiers we can with copious washings, so that ammonia, which is the most offensive to the workmen themselves, is removed as far as we can do so by washing. That is not an expensive process.

Do you know whether it would be equally possible to do it where sulphide of calcium, the result, is produced in the lime—I mean to say, if the means that you take to prevent the inconvenience of the smell were adopted?—Of course, in our method every effort is made to prevent the lime from steaming, and the vapour from passing away beyond the limits of the works; and where the lime is really very moist and steaming to a very great extent, it is covered over with the tarpauling, and with the cold spent lime, and that is the most effectual. That could be applied anywhere.

Does the lime under your process come out of the purifiers in a dry or a wet state?—Not particularly wet, but moist; it would hold together—if you take a handful it would not fall to pieces.

I suppose there would not be considerable increase of expense in applying your process, we will say, to the Crystal Palace works, except so far as it might be necessary to use additional space?—There would not, at all. It is the most ancient process in existence, the purifying process that we adopt.

How far is it from the centre, where you place the lime, to the circumference of your works?—About, I should say, 350 yards from the place of deposit to the road. Purification by oxide of iron is much cheaper than by lime.

Can you give any estimate?—There are a great many estimates, and I hardly know which to rely upon.

How do you store your spent lime, or refuse lime?—We have an enclosure, and when the purifiers are changed the stuff is instantly wheeled there, unless we have an order by rail, and then we put it into the trucks themselves. It is not a covered place, but quite open. Sometimes we have a large stock; we have had as much as 1000 tons.

Would not the covering of the refuse lime with dry earth prevent any smell?—Yes; but the difficulty is, in a place like ours, to get dry earth; and the cold spent lime is equally effective.

Mr. *John Pattinson*, examined by Mr. CRIPPS.

I am an analytical chemist at Newcastle-upon-Tyne, and have been in practice there for about 19 years. During that time I have made frequent examinations of the quality of the gas supplied to the town by the Newcastle-upon-Tyne and Gateshead Gas Company. Since 1869 I have made weekly or bi-weekly tests on behalf of the Town Council, and before that time I made several occasional tests. Those tests included the tests for the amount of sulphur. I have taken the averages out for the last four years. In 1873 the average amount of sulphur in the gas was 7·13 grains per 100 cubic feet; the average for 1874 was 9·4 grains; the average in 1875, 11 grains; and in 1876, 11 grains. The apparatus I used for the purpose of determining the amount of sulphur is that known as "Wright's sulphur test." It consists of a tube about three-quarters of an inch in diameter—a glass tube—which is bent almost at right angles near the middle, and another rod hanging down. In that a small gas-jet is burning, which yields the products of combustion; and for 19 inches of its length it is covered with another tube, and between those two tubes there is water constantly circulating. It is the mode of condensation known as Liebig's condenser. This was the method in use at Newcastle when the Act of Parliament was obtained. Newcastle is one of the places where, by Act Parliament, the amount of sulphur compounds in the gas is limited. The present limit is 17 grains. My testings have been made on behalf of the Town Council, to see whether the Act of Parliament has been properly complied with. There is a slight difference between my testing and the mode of testing adopted by the Referees in London, and I have determined that difference. I have made several comparative simultaneous tests with the Gas Referees' apparatus, employed in the manner described in their Instructions, and with Wright's apparatus, and the difference in the amount of sulphur which they indicate is from one to 1½ grain per 100 cubic feet, the greater being that of the Gas Referees. An average of 7 grains in Newcastle, if it were tested by the London test, would be 8½ grains. The purifying material used at Newcastle during the last 11 years has been almost exclusively lime. Oxide of iron has not been employed excepting, I believe, in one year for a very short time. During the whole of that time no nuisance has been complained of arising from the use of lime purification; the only public complaints which have been made of any nuisance from the works occurred in the years 1869 and 1870. During those years there were very bitter complaints about the nuisance from the works; and there were deputations to the Town Council to ask them to take means to put an end to the nuisance; and at that time I was asked to report upon the source of the nuisance. I examined the works, and found there were several sources. The principal one was from the manufacture of sulphate of ammonia; another, the process of distillation of coal tar; and another, the imperfect and leaky condition of the scrubbers; and the fourth, from waste lime. After my examination the distillation of tar was discontinued. Some time after the scrubbers were put into good order, and the sulphate of ammonia apparatus was very much improved. The consequence has been that there have been no complaints of nuisance from the works since that time. The secretary of the gas company told me, in answer to my inquiries the other day, that he had had no complaints at all for the last two years. If any complaint had been made to the Town Council I should have heard of it undoubtedly, or if any letters had appeared in the newspapers I should have seen them. There are dwelling-houses in the immediate neighbourhood of the works at Newcastle on the east—some three or four rows of houses; there are also houses on the north-east, north, and north-west. The river is on the south, and of course there are no houses there. Within about 300 yards there are houses of a superior description, the rental of which I should think would be from about £30 to £60 or £80 per annum. The lime at the works is dealt with pretty much in the same manner as the last witness described. When the purifier is emptied the

foul lime is put into sacks or bags, and carried on men's backs to the depôt outside the works, where it is emptied down, and is immediately covered over with some weathered lime, or old lime which has been oxidised by exposure to the air, to prevent any bad smell coming from it. After lying in that way for some little time it becomes oxidized itself, and the offensive odour ceases. It is then put into casks and carts, and covered over with a tarpauling of some kind, and in those carts it is removed for about half a mile to a railway siding, where it is put into trucks and sent away to persons who have purchased it—farmers, and so on. I have never heard any complaints of nuisance during that process, which has been going on for a considerable length of time. I believe the use of lime is the best known process for the purpose of purifying gas. There are other processes on trial which may supersede it; but I believe it is the best practical plan. I think that it might be used in London without creating a nuisance. I have made experiments upon the products of the combustion of gas with the view of seeing how far sulphuric acid results from the combustion of sulphur in gas. My opinion is that most of the sulphur is undoubtedly converted into sulphuric acid. When the gas is first burnt I think there is no doubt that most of the sulphur goes off as sulphurous acid; but there is also at the same time some sulphuric acid formed, and I have made experiments to determine that. I burnt a small jet of gas, at the rate of about half a cubic foot per hour, in a Letheby's apparatus—one of the largest sized Letheby's apparatus; and from one-quarter to one-eighth of the sulphur which exists in the gas I found in the form of sulphuric acid. I think that the oppressive feeling felt by many persons in rooms where gas is burnt is due to the presence of sulphuric acid. I am quite aware that the atmosphere of towns contains sulphuric acid and sulphurous acid, and if it were possible to free them from those sulphur compounds I think it ought to be done. There is no practical means of doing that at present, but there are practical means of getting rid of the sulphur in the gas, and that ought to be done, even if it were carried to the point of absolute purity, if possible. It is well known that plants will not thrive in a gas-lighted room, if they are kept there. I attribute that to the sulphurous acid and the conversion of it into sulphuric acid. I think, from my experience, that it is far better the public should pay an increased price than consume impure gas. The whole expense of the purification by lime at Newcastle is only about two-thirds of a penny per 1000 cubic feet, and if twice that amount of cost were incurred, I think none of the consumers would object to it.

Cross-examined by Mr. PHILBRICK: The two-thirds of a penny applies to the cost of purification at Newcastle. I do not know what it may be in London; but supposing it were twice, or even five times as much, it is worth undergoing that expense to get rid of the sulphur. Wright's apparatus, which is employed at Newcastle, gives higher results than that of Dr. Letheby. The difference I found between Letheby's apparatus and Wright's varies from 1·18 grain to 3·57 grains per 100 feet. I do not know why Wright's apparatus was discarded and Letheby's adopted, but it was decidedly a mistake, because Wright's not only gives higher results in sulphur, but is more easy and simple to work. Letheby's apparatus has now been practically superseded in London by the Gas Referees. At Newcastle nearly half the alkali works in the kingdom are established. The alkali does not neutralize the sulphuric acid; I am sorry to say it has the opposite effect. Flowers under glass flourish very well at Newcastle, but on the Tyne, four or five miles below, damage has been done even to flowers under glass from the alkali works. They formerly used Townley Main coal at the gas-works there, but there is none used now. That coal contains very little sulphur. The coal now used comes from the Durham district. I do not know the quantity of sulphur compounds in the crude gas. They do not purify at all in the way suggested by Mr. Patterson. They scrub their gas very considerably, and it is owing to that, I believe, that it is so free from sulphur compounds. The gas is treated with gas liquor, and afterwards with lime. Sometimes the sulphur has jumped up considerably, and I have always found on those occasions that something has been wrong with the scrubbing arrangements—the pumps have gone wrong, or something out of order. The lime from their purifiers

comes in the shape of carbonate of lime, and also sulphide of calcium. I can scarcely say whether they distil their gas at a high temperature; they get about 10,000 feet per ton. I think more bisulphide of carbon is produced when the distillation is carried on at the higher temperature, but I have no experiments upon that point. The highest amount of sulphur impurity I have found in the Newcastle gas is 30 grains, and the lowest about 4·5 grains. For some weeks, with several consecutive tests, I have found 4·5 grains extending sometimes over a period of six months. I believe Mr. Livesey, of the South Metropolitan Company, has tried scrubbing with gas liquor for the removal of the sulphur compounds, but I do not know the process, and cannot speak about it. I am not aware that he has failed in his endeavours to do so. The principal action of the scrubber is to take out the carbonic acid and not the bisulphide of carbon. The latter might have some affinity for the ammonia. The foul lime from the purifiers at Newcastle is covered over with a quantity of weathered lime, which, by the process of oxidation, gets rid of the smell. The lime retains the sulphur until it is converted into sulphurous acid; the action of the air then converts that into sulphuric acid without evolving the sulphuretted hydrogen.

Re-examined by Mr. CRIPPS: When I have asked the cause of a sudden rise in the quantity of sulphur in the Newcastle gas, the explanation has very often been, that there was something wrong with the scrubbers. This leads me to think that there is a great connexion between the operation of scrubbing and the presence of the sulphur compounds.

By the COMMITTEE: I have several times been present at the opening of the purifiers. I have not observed that the workmen employed on those occasions have suffered from the operation. If they ever have to complain of their eyes being affected, I should think that would arise from the iron purifying, not the lime; from the evolution of ammonia. I attribute the stuffy or offensive feeling experienced in a room lighted with gas to the evolution of sulphurous acid, and the large quantity of carbonic acid which is also present. I believe it is injurious, but, perhaps, not appreciably injurious, to a healthy person; to a delicate person I think it would do harm. I have never seen the works of the Crystal Palace District Gas Company.

Mr. *Stephen Smith*, examined by Mr. CRIPPS.

I am a member of the firm of Stephen Smith and Sons, who carry on business at 35, King Street, Covent Garden, as silversmiths. For some time past we have been annoyed by what we believe to be injury to silver from the gas burning. It is an observable thing to any one connected with our trade, the moment one enters into it. We find that the labour required to keep our stock in order during the summer months, when we do not burn much gas, is very much less than in the winter months when we do; it would probably be about half during the summer months. In our trade a very considerable expense is incurred in order to carry off the fumes of burning gas by proper ventilation. I may mention that I rebuilt the premises I am in about seven years since, and I went to a very great expense buying sun burners, and providing other artificial ventilation in the roof, for the express purpose. We formerly took stock as we could, and for two or three years the labour in cleaning the stock has been so severe, from its being exposed to the gas for about three hours at night, that last October we adopted the system of taking stock in early morning with most satisfactory results, and the difference was something very extraordinary. On those occasions the whole of the stock has to be exposed—it is not even kept in the glass cases, but it is all put out to be identified, and of course it gets the worst effect it can from the bad atmosphere. I find that silver goods which have been exposed to the fumes of gas burning for some time have a sulphurous smell about them. That would hardly be the case with goods kept in glass cases, but speaking of factory goods, which we are not so particular about the exposure of, where they might perhaps be for a month or six weeks lying in a place uncovered, it is exceedingly strong and most offensive; and with regard to the surface, my foreman has called my attention to the fact that it seems to bite into the surface, so that it has almost to be

removed again by polish. My father was partner with Messrs. Elkington originally, and I was consulted in the original scheme of opening their London establishments, and for some years after we opened it nothing but oil lamps were used for that reason. Then I may say that these rooms ten years since were very much enlarged, and it was impossible to carry on that system, and we were obliged to give it up, and now we have gas as other people do. It is the case, however, that in some two or three of the old-fashoned style of shops, lamps are still used for that purpose, despite all the cost of them, to avoid the sulphur.

Cross-examined by Mr. PHILBRICK: Having regard to the injury done to goods in our trade, I should avoid exposure to the gas. There is nothing I caution my customers so much against as allowing their servants, after plate has been used, to leave it exposed all night. The result of that will be that the sulphur of the gas will settle down upon it, and the most extremely bad results arise. I do not represent to the committee, that the gas in London injures plated goods more than the gas in Liverpool, or Manchester, or other large towns. The constant remark that I hear from Glasgow houses is that it is worse than it is in London. The expense in my establighment is £150 or £200 a year merely for cleaning, and that kind of thing, beyond what it would be if we could get a pure atmosphere. I do not say it is all owing to the gas. I am not attending to business so closely as I did, and therefore I cannot answer the question, whether the matter has got worse rather than better, but I have not heard our people speak of it. Where gas is burnt there is always more labour in cleaning plate in winter time than in summer. The sulphurous smell I spoke of is only on the metal surfaces of goods in the workshops. I am not aware that other surfaces are affected by it. I do not know what else it can arise from than the gas.

Re-examined by Mr. CRIPPS: This is considered so much a matter of course, that if you asked even a porter who has been employed in the silver trade what it is that tarnishes the silver, he will tell you it is the gas.

Mr. *James Slater*, examined by Mr. O'HARA.

I am a partner in the firm of Holland, Son, and Slater, carrying on business at No. 16, Jewin Crescent, as manufacturing silversmiths. When I was first in business I did not burn gas. As my business increased, and buyers came in late in the evening, I was obliged to take to it, but though I took to it, I did it very unwillingly, and used it with very great distaste to myself. I found the evil effects of it, even in fine weather, upon my goods. Those effects were most seriously aggravated in foggy weather; gas and fog combined, I think, are the two evils that we have to contend with in London. In less than half an hour after the gas has been lighted, the goods in the upper part of the room in glass cases, near the ceiling, suffer the soonest; but to me it only seems to be a question of time and the size of the room. You have only to get on a pair of steps immediately the gas is lighted, and put your head up to the ceiling, and you feel the heat. After the gas has been lighted a little longer you need not go so near the ceiling to feel the effects from the gas. If you have goods on a table, at the level of that at which we are now sitting, they will be affected. You may say, "Then why not ventilate your room?" That is another weak point in London; people do not ventilate their rooms. I keep fires sufficiently large to keep the whole place thoroughly warm, which is of the highest importance with a stock like mine. I tried gas for the purpose, and had to abandon it in less than a month, for though I obtained heat, the smell was excessively unpleasant.

Cross-examined by Mr. PHILBRICK: I know it is, as a matter of general opinion, that the atmosphere of London and other large towns always contains a portion of sulphuric acid, and I am perfectly aware of the injurious effects produced by exposing plated goods to it.

The CHAIRMAN: Was the injury that you described, as occurring in rooms where you did burn gas, a kind of injury that would arise from the action of sulphuric acid upon plated silver?

Witness: Without being a chemist or a scientific person, I say decidedly so; and if the committee will permit me, I will give a very striking illus-

tration of the difficulty I had to contend with. In my early career, when I objected to the use of gas, I had the misfortune to have some cases wrapped in a peculiar kind of paper. The goods got perfectly black. I had the paper tested, and it was coloured by some mercurial process. I had it removed and plain paper furnished, and my goods were kept with very great satisfaction. Then I introduced gas into the place, and in a smaller degree I had precisely the same results that I had had with the mercurial paper. I am not attempting to go into the question whether mercury and sulphuric acid have the same effects, but I am speaking of a practical result—that, upon the introduction of gas, my goods, if exposed to the action of gas, become tarnished in the same way, and the effect of this matter was so insidious, that instead of its being able to be removed quickly, it took the men some considerable labour. Our goods are polished —that is, polished by a man with rouge on the ball of his hand, and he had to do that. That I suffered from most.

And you attribute that to the effect of the gas, do you?—I make no doubt of it.

Do you desire that it should be purified of this sulphurous element?—I certainly do; and I am very much interested in gas operations. I am very sorry that there should be any depreciation in the quality of the gas, because when a fog comes on suddenly, there is a very short supply, and there is very great difficulty in getting adequate light. In my own house I would not have gas if it were given to me.

But you are not analyst enough yourself to say to what element in the gas this was due?—No; I should be sorry to say anything but what comes under my own practical experience.

The CHAIRMAN (to Mr. Cripps): Have you any other witness to call?

Mr. CRIPPS: I have no more evidence of this class to put before you. There is one other witness upon a different matter. Of course, there comes a time when we must take the responsibility of adapting our evidence. I only wish to guard myself to this extent by saying that I must not be taken to have exhausted the evidence on behalf of the Metropolitan Board and the Corporation. I may have to call further evidence in another case.

The CHAIRMAN: Do not understand me as wishing to stop any evidence that you may have to give.

Mr. CRIPPS: Quite so, sir; but one has to exercise a certain amount of discretion in this matter.

Mr. *Samuel Edwards*, examined by Mr. CRIPPS.

I am clerk to the Lewisham District Board of Works. That district is supplied by the Crystal Palace Gas Company to a great extent, and also by the Phœnix. Two-thirds of the inhabitants of the Crystal Palace district, I think, are within the Metropolis. I am generally familiar with the district. Within the Metropolis there are 1096 public lamps lighted by the Crystal Palace Company, and 516 beyond. The former are in Lewisham, Penge, Lambeth, and Camberwell. I know the works of the company very well; they are about a mile from the Palace. The Lewisham District Board of Works are the sanitary authority of the district, and also the authority for the execution of the Nuisances Removal Act. There has been no complaint of nuisance or annoyance at these works from the use of lime, except on one occasion, when the case was investigated, and it was shown——

Mr. PHILBRICK: Do not tell us what was shown.

The CHAIRMAN: How was it shown?

Witness: It was shown by an investigation by the Board of Works. I was not present. It was information that was given to me.

Mr. PHILBRICK: This gentleman, sir, is an officer of the Board who lays informations and takes out summonses against the companies. I rather object to a witness of that class giving evidence of this kind. I would rather he should confine himself to what he knows.

Mr. CRIPPS: The Lewisham Board of Works are the sanitary authority, and he would know of any complaint made to them, and I am asking with reference to that so far as within the Metropolis, of course. (To witness:) You say there was a complaint made some time ago?

Witness: There was a complaint of the river being polluted.

Not a complaint from the use of the lime of the gas-works or the lime purification?—Well, it was incidentally so.

That is to say, the river was polluted by this impure lime being put into it, or carried near it, or something of that kind?—I can explain the exact circumstances. The explanation which was given to me as clerk of the Board of Works, and upon which I decided that no proceedings should be taken against the company, was this—that the lime had been removed and put into a pit in a brickfield some mile from the works, and that, in consequence of a very heavy rain, this pit had overflowed, and carried the liquid into the river, and the injury that was done thereby was of very short duration. I thought it was a pure accident, and therefore no proceedings were taken. That was the only complaint of the use of lime.

You, as representing the sanitary authority, would know the feeling of the inhabitants generally. Are you aware whether the proposal now before this committee is altogether unsatisfactory to the inhabitants there, and undesirable?—I believe it is, and much objected to by the Board for which I act. They object to what is proposed to be done by the Bill before the committee.

The CHAIRMAN: Have you heard no complaint as to the smell when the purifiers have been cleansed?

Witness: No. none whatever.

Have you observed that smell yourself?—No, I have not; the railway goes into the works in close proximity to the purifiers, and, if there was a nuisance, of course it would be complained of.

I suppose you have never been present when the purifiers have been cleaned, have you?—No, I have not, and practically all the adjacent houses are on one side, the north, south, and east sides are open fields.

It is becoming an increasing neighbourhood, is it not?—It has been increased very much within the last 20 years, and is increasing, but it is flat land, north, south, and east. It is in the valley very near the river, and in a very ineligible place for building. I live three or four miles off, but I am in the neighbourhood very frequently, and in constant communication with the residents. The works are at Bell Green, and very near the Lower Sydenham Station. There are no houses, within a mile of these works, which are not shown upon the plan produced.

Do you happen to know whether the land about there is very expensive, if it was desirable for the company to acquire additional ground?—I should think it was the least expensive ground in that district, from its being flat, and also from the proximity of the works.

You cannot give an estimate of what it is per acre, can you?—No; the land has been recently purchased by the company in extension of their works. The works are about 1000 feet long and 500 feet wide. The purifiers are about 500 or 600 feet from any habitation, and those are the residences of the men employed at the works.

Mr. PHILBRICK, in replying upon the whole case, said: Sir, as my learned friend, Mr. Cripps, on the part of the Metropolitan Board of Works, has concluded his case, the matter is now ripe for the decision of the committee, so far as the evidence is concerned. In the discharge of the duty that I owe to my clients, I must make a few remarks to the committee upon some of the evidence; but I trust that I shall not unduly trench upon your time. Let me first of all call your attention very briefly to the position in which we are as a company. We are a suburban company in a district which has just been pointed out to you, which is becoming rapidly built upon—which is built upon with property of an exceedingly good character—a villa, and a residential, neighbourhood, in the suburbs of London. We are manufacturing our gas, not under the restrictions of the Metropolitan Acts at all; we have been deliberately excluded more than once (and in spite of an attempt of the Metropolitan Board of Works to include us within their net) from the category of metropolitan companies; and I think I may say, I trust not unfairly, on the part of those whom I represent, that there is not the slightest reproach that can be cast upon this company, either in the way in which they conduct the manufacture of their gas, or the way in which they treat their customers

or the public at large. We are here with a directory composed of gentlemen of scientific eminence who manage their concerns with a due regard certainly to the interests of the public; and I do put it to you very strongly that the company have claims on the consideration of Parliament when it is shown to you that with the capital we had it in our power to raise at 10 per cent., we raised £50,000 at only half of that rate. When we came to Parliament again and obtained leave to raise new capital at 7 per cent. (the rate that is now allowed for gas companies on new capital) not one shilling of that capital has been raised, except as absolutely called for by the requirements of the district, and to enable us to supply the gas which we are bound to supply in our district. We have kept down the price of gas to private consumers outside the Metropolis, and in a district where our mains are necessarily long, and not as productive as in a more densely-populated neighbourhood, at the rate of 8s. 11d. I say under these circumstances the company do come with something like a fair case, I do not say for favour, but for the consideration of Parliament, in asking to have the restriction, which they feel to be an oppressive restriction, removed. My learned friend, Mr. Cripps, on behalf of his clients, as to whose opposition I have not one word to say, states that the Metropolitan Board constitute themselves, or are constituted, the guardians of the public interests. They do not seem to have very many of the public in this district, or any one who takes sufficient care or pains about the matter, to come forward here and say, "We object to that which the gas company are proposing to do." They do not bring forward here a single consumer who says, "We think this restriction ought to be kept, and ought not to be removed, because we would rather have the increased purity of the gas and have these sulphur compounds taken out, than have the restriction removed with a corresponding benefit in the shape of a reduction of price accorded to us." But my learned friend says, "Here was a statutory bargain come to between Parliament and the company in 1873; you then had power to raise your capital at 7 per cent., and you had the restriction put upon you of the 20 grains of sulphur." I was very much obliged to one of my learned friend's witnesses yesterday who gave us a history of the matter, I think it was Mr. Heisch, who was in a little difficulty as to the exact time when the restriction came into force. The Act of 1860 had prescribed a certain quantity as a hard and fast line. The Act of 1868 put it upon the Referees to prescribe other conditions that we have all heard of in this room. The Referees did not immediately proceed to discharge their duty in that respect; they awaited the result of certain investigations; and the result of their experience was stated in answer to a question of the chairman, that at the end of 1872, or the beginning of 1873, the present limits, or the limits that were first prescribed, were laid down. Now that is a most important date for me, because in November of 1872 we had given a parliamentary notice for a Bill, which became the Act of 1873. We were before Parliament in the session of 1873, and Mr. George Wilson Stevenson, whom we called before you, was examined before the committee in that year. The regulations of the Gas Referees had just come out, and he, advising as he was the Metropolitan Board of Works, said, in answer to the question, "Don't you think that there ought to be some test for purity?" "Yes, I think it quite right." "What?" said Mr. Horace Lloyd; "ought it to be 20 grains?" That was what he had in his mind; 20 grains was what the Referees had prescribed. That was the first amount settled when they came to discharge their duty under the Act of 1869, and therefore most naturally Mr. Stevenson answered 20 grains; and so, without a single word of comment, without chaffering, I may say, it was accepted at once and put into the Bill, in clause 17, which we seek to alter. So far from that being a bargain, I venture to say this: If it was a question of a bargain it was an unfair bargain, and we come with good grace to Parliament to be relieved from it; but it was nothing of the kind. It really was a restriction put upon us without due consideration at the time, without a thorough appreciation of what the practical working would be, or the difficulties that it would entail, and therefore we come here, finding what the results are, to have it removed. Now, sir, let me be, as I feel sure I can be, in doing ample justice to the case of my clients—let me be candid

with the committee about this. We have had here to-day some evidence that has struck me, and I am sure it must have struck the committee, as being remarkable. We have had a gentleman from Nottingham who tells us of the results. We have had a gentleman from Newcastle who tells us of results that they obtained there, and as to those results, the question arises in a moment, why cannot you do it in London? The answer is, I think, conclusive—because the conditions are different. In the first place, you have at Newcastle, and also at Nottingham, an entire choice of coal, and you have a different coal to carbonize. It may be said we could get the same coal in London; it is a question of money only. The answer is that practically we cannot, and what has Parliament thought was the right thing to do with reference to the Metropolis? Not to lay down a hard and fast line in the matter of these impurities, but to enact that it shall be left to a tribunal—the Gas Referees—composed of gentlemen practically conversant with the subject, from time to time to ascertain with what degree of purity the companies can reasonably be required to make and supply gas continuously without occasioning a nuisance to the neighbourhood; and the Referees do prescribe the maximum amount of impurity that should be suffered to remain in the gas. Now, what have the Referees done? They have said, if you manufacture your gas within a crowded area, on account of the nuisance, injury, or the risk of injury which must inevitably be entailed by the process of lime purification, we will allow you to have a greater amount of sulphur compounds than if you manufacture gas out of the limits of the Metropolis, where the use of lime would not be so objectionable. And I say that what the Referees have done under that Act was a matter that might fairly enough warrant this company in coming to Parliament. But in our case we have a hard and fast line of 20 grains. We supply a district where the houses are not those of a poor class—not an artizan district or a populous neighbourhood, but houses of a superior and villa description, and we are put under a hard and fast line, which is the most rigid line of any company in the kingdom that I have heard of, except Newcastle, and far harder and worse for us than the limits of the metropolitan companies. I say that alone would make a justifiable case for our coming to Parliament. I have called your attention to the particular circumstances of this company, as their local position, and the exceedingly hard limit which is put upon us on this question, places us in a worse position than any of the great London companies. The Commercial Company, who are, perhaps, under exceptional circumstances, are working at 30 grains, which is 50 per cent. more than we are. I dare say it may be altered, but we know that in the winter 25 grains are allowed to an urban manufactory. But I turn to the evidence called on behalf of the Metropolitan Board themselves, and I cannot appeal on that matter to higher authority than to their own consulting chemist, Mr. Keates. And what did he tell us? He said, "I am myself rather in favour of relaxing the limit. I think a little above 20 grains may be allowed, but I think it would be the greatest possible mistake to remove the restriction altogether." And then he is asked: "How much would you give them?" and he says, "I think even 25 or 30 grains might be allowed." I dare say no honourable gentleman could have sat upon a committee without noticing the various phases with which witnesses come forward. Sometimes we have witnesses that will not answer; sometimes we have a witness that wants to talk a little too much; sometimes we have one who is jocular; but here is an answer, not from a person who has come to give a hasty opinion, and from whom an unguarded one is extracted on cross-examination, but a gentleman who is put forward by the Metropolitan Board themselves—their own chemist. My learned friend, Mr. Cripps, with his great experience in these committee-rooms, never asked Mr. Keates a single word as to the expediency of these sulphur tests as applied to this company, but left it; and if it had not been that this question was put accidentally by me to Mr. Keates, one never would have known his real opinion upon the matter. Therefore, the evidence comes before you very strongly indeed; first, from the fact that my learned friends were not instructed to bring it out, or did not bring it out; and, secondly, because they knew that in that way, from his being candid enough, as you might expect from a gentleman,

in his position, and sound enough, I may say, to say, "I think it may be relaxed." I think he said, "When you consider the expediency between a nuisance created and an advantage to be gained, I think 30 grains may be allowed." I do feel a difficulty in this case on another matter, where, upon a question not of absolute truth and verity, but upon a question of degree, Mr. Keates puts it to us as a matter of expediency. He says in one case a nuisance could be created, and possibly on the other an advantage might be gained. No doubt. I never sought to conceal from the committee that having gas absolutely pure would be a great advantage; to have it relatively pure would be also advantageous. It is a question as to what degree of purity can fairly be got. Now, what have we to see to? We have had here to day a number of gentlemen absolute purists in matters of gas, and who think that all gas burning is injurious. I dare say it is. I dare say it destroys the plated surface of silver, more or less, but gas burning, after all, is a necessity; and because of the particular refinement of the silversmith's trade, gas cannot be put out either in public thoroughfares, or in shops and warehouses. I pass that by at once, and I say that that class of evidence can satisfy you of nothing when the question is how much impurity is it right should be allowed to remain; and how much of it the Legislature ought imperatively to exclude? Therefore, I should ask you, when you come to consider it, to look at the quantities of the impurity, and the effect that they have shown to have been produced. We have had here the whole opposition of the Metropolitan Board of Works. It is a singular fact, but it is a fact not without its significance, that they have not brought before the committee a single experiment, or set of experiments, which affect to show the result of combustion of the ordinary gas unpurified from the other sulphur compounds. They have refrained, or, at least, they have not been able, to bring before you any results of the condensation of gas which contained, as Dr. Odling's and Mr. Russell's experiments did, 33 grains of this sulphur compound in 100 cubic feet, but they content themselves with bringing to your notice the evidence that has been referred to the committee by order of the House—namely, the evidence given before the committee of 1866 or 1867. They have referred to that, and they have called before you one or two chemists, and they have—well, I was going to say, produced before you a portmanteau, which Mr. Heisch very prudently withdrew. We have not had proved a complaint on the part of a consumer in the Crystal Palace district, nor of a consumer of gas at all, except that of a gentleman who says: "I would not use gas at all, pure or impure; it affects my wires." You have not, I say, a single complaint of any consumer, with regard to gas. True, it is said that brasswork is injured; but, apart from the sad instance of two or three crystals of copper found on the bell-wires in Dr. Frankland's house at Lancaster Gate, I have not heard of any brasswork actually injured. Some one of the witnesses said that there was not so much injury on the floor, that the bright places on the grates and stoves were not injured—I think it was Dr. Frankland who said so—or not so much injured. I pressed him, and he said there was no injury in that part of the room. Well, I asked, in the upper part of the room, where the picture rods and wires were; was there much upon them? I could not make out from him that there was any definite or tangible amount, nor could I make out that the heated zone, in a badly-ventilated room, where gas was burnt, or, indeed, where oil was burnt, was due to sulphur or sulphur compounds. It is said that you have sulphurous acid gas. I agree you have sulphurous acid gas at the point of combustion, but you have no sulphuric acid at all. We were told by Dr. Frankland that the greater the ventilation the better the condition of the room, and the more likely was it that a minute quantity of sulphuric acid would be produced at once, but if you have the condition of ventilation, with sulphuric acid produced, you have that condition in a minute degree, but rapidly carried off; whereas if you have a hermetically sealed hot box in which these products are placed, you have a condition which prevents that combination, and therefore you have sulphuric acid. Then it is said, as long as it is hot it is all very well, but afterwards, when cooling takes place, there occurs condensation and precipitation. If there is precipitation, one would suppose that on the articles in the lower portion

of the room you would find the effects of that precipitation; that it would fall down, and that that which had been in suspense in the heated atmosphere above would descend and make its effect apparent on all that was in the room below. But do we find that? I venture to say that the whole of that portion of the evidence is speculative, assumptive, theoretical, and not practical and reliable. And then, when we come again to the statements of Professor Barff, who gave his evidence with singular candour and fairness, he told us undoubtedly that sulphuric acid, even diluted, will affect ultramarine with certain zinc pigments in it, and if it continue long enough, it will destroy the fabric and fibre of the hemp canvas itself. Agreed, but does it practically do so? It is said these compounds do the mischief. I answer by pointing to Dr. Oldling and Mr. Russell, whose figures, and theories even, have not been combated; those experiments have been untouched by any of these gentlemen, and not in any degree controverted. None of the witnesses say that these sulphur compounds have any influence upon the health of healthy persons. I think one of them did say it might occasion distress and suffering in the bronchial tubes, or in breathing to an invalid; but the answer was clear, first of all, that the quantity which was respired was the quantity which was in the middle zone of the atmosphere which Dr. Odling described to you, and was very minute in it; it is not what is in the zone next above that an invalid would be subject to in the least. These conditions are not generally found, but are conditions when gas which is charged with these compounds is burnt, all the products of combustion most carefully condensed and saved for the purpose of giving you, not what actually occurred, but what could by any possibility occur in the worst condition of things that could possibly exist. Now, sir, I say, in the face of that, that there is nothing beyond the merest speculative opinion upon the part of these gentlemen that these sulphur compounds really do cause detriment. The conditions of burning in a laboratory for the purpose of chemical results are far in excess of anything that is really effected in the ordinary method of combustion. When it is said that these impurities are very objectionable indeed, producing the stuffiness of the rooms and the atmosphere, and so on, the answer is that a good deal of carbonic acid is necessarily evolved during the progress of combustion. That must be so whatever your gas contains, and the nausea and headache are the consequences. I think one of the witnesses said it would possibly account for these results. The answer, I think, is that there is abundantly sufficient to account for it in the presence of carbonic acid, and the matters that have been referred to, without putting it down to sulphur. I will not weary the committee upon this any longer, except to make one concluding remark. We have heard a good deal about the outcry against sulphur. It is supposed to be the parent of all these evils. I say deliberately, after having heard all that has been stated, that there has not been traced home to these other sulphur compounds any one of these evils. If they do exist, they can possibly be assigned to other causes. It has not been proved that they arise from the sulphur. Then let me ask where is the harm of allowing this company to manufacture their gas in the way they propose to do? It is not supposed for a moment that they are going to force sulphur compounds upon the public from any desire on their part. They admit them to be objectionable. They would be glad to get rid of them, but they object to be under this restriction as to the use of lime in their neighbourhood. It is not a question of cost. If it were a question of cost in removing the lime merely, I should not be here to ask you to remove the restriction; but we submit that the best test of the difficulty of working is one of the elements in it. One of the witnesses said there was no annoyance to the men who discharged the purifiers, but he was speaking of the time when the old lime process was in use, and not of the state in which these horrible products are employed to absorb the sulphur compounds, in order to carry out the system of the Referees. Mr. Livesey told us that though the men had masks on, and he had practically tried all kinds of things, the men did complain bitterly of it. I do not wish to make too much of that, yet it is one of the matters attending the manufacture of gas under the condition in which we are. I venture to say that no case has been made out why we should be dealt with in a worse way

than the metropolitan companies, and I say that the evidence which has been given on the part of the Metropolitan Board has shown that 30 grains might be conceded to us, or half as much again as we have now. But I am asking you to remove this restriction altogether, not, as I say, that we would import a single impurity into our gas, but that we may carry out to perfection our own purification by the peroxide process, and not be driven to the necessity of having the lime in the condition that we have to use it. It is said that there is no great nuisance to the neighbourhood; but then we have to work always under the fear of penalties, with the knowledge that a nuisance may arise at any moment, beyond our control. We have to work always to the standard, and whereas under the more favourable conditions of the London companies, who are allowed a three days average, we are on a hard and fast line of a single day, and may be sued by the Lewisham Board if we transgress by only half a day. We have also the knowledge that tests are not particularly accurate, even though there is great experience used in making them. We have the fact further, that these sulphur compounds themselves are not proscribed in any of the cases in which the Board of Trade grant Provisional Orders. They are not proscribed in any case in which corporations carry on gas-works throughout the kingdom. They are not proscribed in Paris, where works of art are considered, and as highly thought of, as they are here, and where our neighbours are as particular as we are. I venture to submit that upon the whole of this case the only solid and definite ground under your feet to go upon is that found in the actual results of the experiments made by Dr. Odling, by Mr. Russell and Mr. Stevenson, and that those results show how utterly unfounded is the cry that has been taken up, "*Omne ignotum pro terribili est.*" They did not know what it was, and therefore they were afraid of it. The moment you test it you see the result, and find that there is nothing in the presence of these few occasional grains of sulphur compounds, the presence of which can fairly be said to be the source of these evils. It is not a question of trying to get rid of them altogether; no one pretends that it is the question of adapting any one of these processes suggested, none of which have been carried into operation, but it is a question of reducing from one-fifteenth to one-tenth the total quantity of these. I venture to say that the company have made out their case, and even upon the evidence that has been given I respectfully ask the committee to declare the preamble proved.

The committee-room was then ordered to be cleared, and the committee consulted. After some time the counsel and parties were called in, and

The CHAIRMAN stated that the committee had decided that the preamble of the Bill was not proved.

THE GASLIGHT AND COKE COMPANY BILL.

WEDNESDAY, MAY 9, 1877.

Mr. POPE, Q.C., Mr. RICHARDS, Q.C., and Mr. MICHAEL appeared for the promoters; Sir E. BECKETT, Q.C., Mr. CRIPPS, Q.C., and Mr. O'HARA for the Metropolitan Board of Works and the Corporation of the City of London, petitioners against the Bill. The Board of Trade were represented by Mr. ROUND.

Mr. POPE, in opening the case for the promoters, said there was a very grave distinction between the case of The Gaslight and Coke Company and that of any smaller concern in the country, where, whatever might be the regulations prescribed, either by Act of Parliament or by the action of the Gas Referees, the processes could be so much more easily dealt with, and the results of those processes disposed of with so much greater facility. When it was recollected that The Gaslight and Coke Company represented, in fact, the gas supplied to very nearly three-quarters of the Metropolis, it was obvious that the questions involved affected not only great interests on the part of the company, but equally large interests upon the part of the consumers; and it was matter for rejoicing that the whole question would be thoroughly sifted by the gentlemen who were interested upon the part of the public, and who would take care that the whole matter was investigated so far as might be necessary for arriving at a decision. Originally the Chartered Company was one of thirteen companies supplying the Metropolis with gas; but, in pursuance of powers conferred upon them by Parliament, they had gradually absorbed most of the companies north of the Thames, and thus constituted one large undertaking. The gas companies which were merged in the Chartered Gas Company were the Imperial—which was the latest amalgamation, in 1875—the Independent, the Western, the Equitable, the Victoria Docks, the Great Central, the City of London, and some other smaller ones. The Gaslight and Coke Company manufactured gas at ten stations, but there were, of course, other stations which were not manufacturing, and others which had been abandoned. As the committee were aware, the Chartered Company some years ago extended their works to Beckton for the express purpose of carrying a large proportion of their manufacture as far as possible out of town. The largest manufacturing station, therefore, was at Beckton, and the gas manufactured there was conveyed by mains passing through the Commercial Company's district. The actual acreage which the company had at Beckton was about 150 acres, of which some 70 or 80 acres were covered with buildings, and the remainder of the unoccupied land there was used for the deposit of the foul lime which was the result of the purifying process at their various stations. Passing towards the west from Beckton, The Gaslight and Coke Company had another manufacturing station in the immediate centre of the Commercial Company's district, which they did not, of course, supply; and passing still further west they had the station at St. Pancras. Both Shoreditch and St. Pancras were formerly stations belonging to the Imperial Company, and the committee would find, with reference to those stations, that, having changed hands since 1875, the same processes which were resulting in difficulties with them were

still resulting in difficulties with the Chartered Company. There was also a manufacturing station at Lupus Street, Pimlico, on the margin of the river, close to the neighbourhood of St. George's Square—a neighbourhood of which the committee would hear a good deal in the course of the case. The stations in London of The Gaslight and Coke Company's district were a manufacturing station at Fulham, and a large station at the extreme west at Kensal Green. The committee had already been made acquainted, in the course of the inquiry which had taken place, that the insisting upon a certain amount of purity from sulphur compounds was practically insisting upon purification by lime; and the two questions which arose as regarded the public and as regarded the nuisance, were simply, first, as to the nuisance arising from the process in the neighbourhood where it was carried on; and, second, what was to be done with the enormous mass of refuse which was the result of that process. The latter point, it would be seen at once, in the case of The Gaslight and Coke Company, immediately assumed an importance (simply by reason of the size of the operations carried on) which it did not assume in the case of a small company where they were dealing with a comparatively small manufacture of gas, and had only a limited amount of refuse to dispose of. In the present case, when the committee were told that the amount of refuse lime deposited by The Gaslight and Coke Company covered an area of ten acres of land to a depth of nine feet every year, it became a very serious question, what was to be done with it, if purification by lime was insisted upon as a statutory matter. At Kensal Green—the extreme west, and with no immediate access to the river—they did the best they could in disposing of their lime upon the spot; but with that exception, all the spent lime had to be conveyed either by river direct, or partly by canal and river, to Beckton, where it was spread upon vacant land, Beckton being out of the reach of those who complained of the nuisance; but it would be for the committee to consider whether, dealing with a question of that magnitude, that disposition of refuse could go on for long, because, unless some means other than the use of lime could be discovered or suggested for the purification of gas from the sulphur compounds, the day must come, and at no distant date, when there would be no means for the disposition of that refuse lime, unless it were taken into an estuary of the sea, and thrown into the water, when they would doubtless have Hastings, St. Leonards, Margate, Ramsgate, and all the watering-places, coming to Parliament and complaining of the enormous nuisance deposited by the tide upon their beaches. That being the exact state of facts as regarded the manufacture, he (Mr. Pope) would point out what the position of The Gaslight and Coke Company was. The committee would find that, whether during the course of transit or during the process of emptying the purifiers, from the neighbourhood surrounding those works, constant and most serious complaints were made of the nuisance which was created at Shoreditch, at St. George's Square, at Fulham, and all round the districts where the works were surrounded by habitations; not only sentimental complaints, but complaints which had culminated in threatened indictments, and in a real public nuisance to those who surrounded the works. Upon that point evidence would be called as to what the real matter was; and the committee would doubtless be satisfied that whatever nuisance was occasioned, by the use of the lime system of purifying, was inevitable in the use of that system; but every possible suggestion which could be offered in order to minimize the nuisance was adopted, and the greatest possible care was taken to prevent it from being a nuisance to the neighbourhood. It could be well understood that, although the passing of a load of spent lime simply caused a smell which was obnoxious for an instant, and which did not seem to be a serious nuisance, yet it would be found that the result of personal experience upon all hands was, that those who made light of it at first very soon came to regard it with respect; because, although at first the smell was slight, and the nuisance not very intolerable, the result of it in the disturbance of the bodily economy was very considerable indeed; and that was exactly the description of the state of matters, notwithstanding all the precautions that could be taken, where the stations were surrounded, or were in the centre of great populations. By the City of London Gas Act, 1868, Gas Referees were appointed for the first time, and provisions made with regard to their powers of testing the illumina-

ting power and purity. The 29th section was as follows:—"The Board of Trade shall, as soon as may be after the passing of this Act, appoint three competent and impartial persons, one at least of them having practical knowledge and experience in the manufacture and supply of gas, who shall be called the Gas Referees (and who are in this Act referred to as the Gas Referees) and in case of a vacancy happening among them by death, resignation, or otherwise, shall appoint a competent and impartial person to fill the vacancy, one at least of the three being always qualified as aforesaid." It was obvious that the Legislature in 1868 felt that the circumstances involved in testing for purity, and in the regulations made for securing the purity of gas, were of so special a character, that one at least of those who were to have any control over the matter, and in whose discretion a great power was placed, must be in point of fact a practical gas manufacturer, who would be acquainted with the difficulties of dealing with the question as a matter of practical manufacture, not as a matter of laboratory chemistry; and the worst that could be said of the tribunal seemed to be, that it was difficult to secure, under the provisions of that section, the competency and impartiality united which were so desirable, because if they had a gas manufacturer, he, generally speaking, must be connected with one of the companies, and could hardly be called impartial, although he was competent; but, on the other hand, the section itself seemed to indicate that if they had a chemist who might be perfectly impartial, not being connected with gas manufacture, he could hardly be reckoned as competent. The main source of difficulty, therefore, arose, not from any want of knowledge theoretically upon the part of the Referees, but upon the difficulty of associating with theoretical knowledge the peculiar competency which was recognized by the section, and which competency of itself necessarily gave a certain bias and want of impartiality. He (Mr. Pope) would at that point say, once and for all, that although probably it might be necessary to criticize what the Referees had done, he should do so in a spirit not only of the greatest respect, but of the most sincere acknowledgment of the honour and knowledge which they brought to bear upon the subject, and it was simply because that tribunal was found to be unworkable from the very nature of its constitution, and the powers which were committed to it, that the inconvenience was found to arise for which a remedy was now sought. By the 36th section it was enacted that "The Gas Referees shall from time to time ascertain with what degree of purity the said company can reasonably be required to make and supply gas continuously without occasioning a nuisance to the neighbourhood in which the works are situate, and shall thereupon prescribe and certify the maximum amount of impurity in each respect with which gas supplied by the company shall be allowed to be charged, and the time from which the allowance thereof shall be enforced as against each company, regard being had to the necessity for any alteration of works by a company consequent on any such certificate." Taking that section in connexion with the provision as to the competency and impartiality of the Gas Referees, it would seem to be as elastic and as favourable to the gas companies as possible, but the experience of the few years which had elapsed had shown that, although it appeared to be elastic, it was, in fact, so arbitrary and so inconvenient that there was no resource left to the companies excepting to ask the interference of Parliament for its modification. The first Referee who was appointed was a gentleman who had been connected with the manufacture of gas, and who on all hands was admitted to be a gentleman of the highest competency, and certainly having practical knowledge and experience in the manufacture and supply of gas, and with him were associated two other gentlemen. Finding the extreme difficulty of prescribing the amount of sulphur compounds, so long as the Referees had the advantage of a practical acquaintance with the supply of gas, they declined to prescribe any specific amount of impurity, but declared that the companies must keep a register of the amount of sulphur impurity, in order that the matter might be fully and freely investigated, both as to its result on the consumers, and its possibilities with regard to the companies. Mr. Evans subsequently resigned, and his two colleagues, Mr. Patterson and Mr. Pierce, having become connected with some large coal supply, were not re-appointed on the termination of their year of office.

The COMMITTEE: The only impurity we are asked to consider is the impurity of the sulphur compounds?

Mr. POPE said quite so. There was no complaint whatever about the sulphuretted hydrogen or any impurities about which regulations were made. Mr. Evans resigned because it was felt by those representing the consumers that they could not regard him as impartial, he being a gas engineer, and that really showed the unworkability of the section.

Mr. O'HARA: Was he not the engineer to the Chartered Company, and not a gas engineer merely?

Mr. POPE said that was the case. The present Referees were Mr. Vernon Harcourt, Dr. Pole, and Professor Tyndall. Without saying more as to what their powers were the result was that they had prescribed that in the gas made at Beckton, Bow, and Bromley, the maximum amount of sulphur allowed should be 15 grains per 100 cubic feet; for gas made at the other works of The Gaslight and Coke Company, and for the works of the South Metropolitan Gas Company it should be 20 gains, and for the gas made at the works of the Commercial it should be 30 grains. Those regulations were to be enforced from March 31, 1877, until superseded by future notification. It was, however, only right to mention that that was a notification for the summer part of the year, the previous notifications which would bear upon the winter not being quite so severe, because they allowed a further margin of 5 grains, being 20 grains to Beckton, Bow, and Bromley, and 25 to the other works of The Gaslight and Coke Company. The plan adopted by the Referees from 1868 to 1872 was as follows, adopting their own words:—"The gas shall be considered to be impure, rendering the company which issues it liable to the penalties prescribed in the Act, when it contains more than 5 grains of ammonia in each 100 feet, or when it shows the least trace of sulphuretted hydrogen. The quantity of sulphur compounds other than sulphuretted hydrogen shall, until further order, simply be recorded."

The CHAIRMAN: Was that system of fixing a certain number of grains adopted in 1872?

Mr. POPE said it was, and was continued up to the present time—at first not so strictly as now, but for the last two or three years it might be taken that practically the notification he had given the committee had prevailed and was prevailing at present, of 20 and 25 grains.

The COMMITTEE: During the period when these things were simply recorded, were there occasional remonstrances, regarding the sulphur compounds, addressed to the company?

Mr. POPE said at that time the lime process was not used, and there were none of the complaints as to the nuisance. According to the present condition of things it was perfectly plain that, to comply with the decision of the Referees, purification by lime was absolutely essential. The company were between two fires—they were threatened with indictments for their purification, and with penalties for non-compliance with the Referees; and, although it was perfectly true that in 1876 the penalty provisions were relaxed, in a sense, making them penalties on an average amount, and not on any particular delinquency on any particular day, still they were subject to penalties on the one hand, and indictments on the other, and it was a difficulty from which they very naturally desired extrication. Dealing with the question of what Parliament intended with regard to this matter, he (Mr. Pope) would ask the committee to refer to the Act of 1871, which amended the Gas-Works Clauses Act of 1847.

The CHAIRMAN: Is the penalty under the 74th section of the Act of 1868 £50 a day?

Mr. POPE: Yes, sir.

Mr. O'HARA: That is all changed now.

Mr. POPE said it was only changed in the sense he had mentioned. It was £50 a day, but instead of being a penalty, as it was in 1868, for every day, it was modified by section 51 of The Gaslight and Coke Company's Act of 1876:—"If on an average of three days the gas supplied by the company from any station is of less purity than it ought to be under this Act, the company shall forfeit a sum of £50 for each station in respect of which they are so in default;" so that instead of being a penalty of £50 a day for one day, they had taken an average of three days, with one

penalty of £50, and then another three days would be another penalty of £50.

The COMMITTEE: It might come to the same thing in the way of penalties. Monday, Tuesday, and Wednesday are three days, and Tuesday, Wednesday, and Thursday are another three days.

Mr. POPE said he hardly thought they could inflict penalties in that way, because it would not be another three days. If the committee turned to the Gas-Works Clauses Act of 1871, at section 12 they would find all the provisions which in 1871 were thought necessary to be made with regard to the question of purity:—"The quality of the gas supplied by the undertakers shall with respect to its illuminating power be such as to produce at the testing-place provided in conformity with this Act a light equal in intensity to that produced by the prescribed number of sperm candles of six in the pound, and such gas shall as to its purity not exhibit any trace of sulphuretted hydrogen when tested in accordance with the rules prescribed in that behalf in Part II. of the Schedule A to this Act annexed." In other words, in 1871, for companies not under the jurisdiction of the Gas Referees, no provision was made for any sulphur compound except sulphuretted hydrogen; and of course all gas-works which were regulated by the Gas-Works Clauses Act had no provision with regard to sulphur impurity, and it was unnecessary for them to incur any of the disagreeable alternatives which the action of the Gas Referees had placed upon his clients. Passing to the Chartered Gas Act of 1876, the committee would see that from section 27 onwards there were re-enacted, subject to the modifications of section 51, the penalties to which attention had been previously called, and which were as binding upon the company as the other provisions of the Act of 1868. Section 30 re-enacted exactly the provisions of the 36th section of the Act of 1868 already quoted, subject to the modification by section 51, the penalty being calculated upon an average of three days, instead of under section 74 of the Act of 1868. This was the position of the company at present, and he (Mr. Pope) would briefly state what they asked the committee to do. The company found themselves between two fires. They found, whatever might be the appearance of elasticity about these clauses, that they were, in fact, arbitrary and unworkable, and, therefore, the Bill before the committee asked that those powers and those provisions might be entirely repealed. It was quite possible they might come to the conclusion that some restriction, at all events upon sulphur impurity, was desirable; but if that were so the company contended that it would be entirely within the province of the committee, while not repealing those provisions, so as to leave the company absolutely and entirely free from restriction, as they would be if they were not under the Gas Referees at all, so to relax those provisions as to introduce as an instruction or a control upon the Referees, fixing a minimum amount, beyond which their discretion should not pass, and which would, in the words of the Act of Parliament, render it possible to maintain a "reasonable amount of purity," without causing a nuisance to the public. The words of the statute were: "That the company is to be required to furnish gas with such an amount of purity as they can reasonably be required to make, and supply continuously without occasioning a nuisance"—words very large, words very wide, words which seemed to indicate that Parliament had at that time in its mind the very difficulty which had arisen, and from which the company were unable to escape, and as to which there was no use throwing off to the future the discussion of a question which, after all, had better be discussed at that time. The company therefore asked to be taken out of the jurisdiction of the Gas Referees as regarded sulphur impurities, though not as regards any other sort of impurity. If the committee doubted the prudence of that, at all events they might grant relief by putting such a minimum as would prevent the company being reduced to the uncomfortable position in which they found themselves, and from which they asked equitable relief from a committee of Parliament.

The CHAIRMAN: Was this clause objected to when you sought your Bill last year?

Mr. POPE: I think not; I have made inquiries, and I think there was no fight upon the Bill of 1876.

Mr. O'HARA: I may say that when the clauses in the Bill were settled it was a matter of convenience to them, and the three days average was the only thing the company struggled for; the degree of purity was not objected to, but it was said to be a hardship that the impurities of any one day should be taken as a test, and therefore it was agreed that the average of three days should be substituted. The action of the Referees was not objected to, only the mode of enforcing the penalty.

Mr. POPE said no doubt that was so; but the real truth was that The Gaslight and Coke Company's Act of 1876 was passed before the result of the amalgamation with the Imperial Company had really been ascertained. At that time the Chartered Company were removing their manufacture to Beckton for the purpose of getting rid of the particular difficulties which would cluster round their works, but on their amalgamation with the Imperial Company they also acquired the *damnosa hereditas* of that company. As had been already pointed out, the Shoreditch, the Haggerston, and the Fulham stations were all legacies brought to the Chartered Company by the Imperial, and it had really only been since they had become amalgamated that the difficulty had arisen of carrying on that process in manufacturing stations surrounded by dense populations.

The CHAIRMAN: I wish to know whether any of the directors who obtained this Act in 1876 had had experience before that of the control of the Referees?

Mr. POPE: No doubt the Chartered Company were always under the control of the Referees.

The CHAIRMAN: I mean to say including the Chartered Company, because they had their works at Beckton, and they did not suffer so much.

Mr. POPE: What you wish to know is, whether it was the Imperial directors or the amalgamated directors. Mr. Phillips tells me that they had joined The Gaslight and Coke Company's board immediately before the Act of 1876 was passed.

The CHAIRMAN: Therefore, having had experience of the Referees when they were directors of the Imperial Company, they made no struggle against this clause.

Mr. POPE: That must be accepted as a fact.

Mr. O'HARA: That is the fact, and must be accepted as such; but the way the Act of 1876 came to be passed was this: The matter had been contested hotly in 1875; but the Bill was not proceeded with in consequence of the lateness of the session. The main provisions of the Bill of 1875, settled before Mr. Forster's committee, were re-adjusted by agreement between the Companies and the Metropolitan Board of Works, the Corporation, and the Board of Trade.

The CHAIRMAN: Then there was a discussion about it before Mr. Forster's committee?

Mr. O'HARA: No, the discussion about the average took place upon the settlement of the Bill by consent in 1876.

Mr. POPE: That is as to the average of three days, but what the chairman was asking about was, whether this old purity question was before Mr. Forster's committee.

Mr. O'HARA: Undoubtedly it was fully discussed there.

Mr. POPE: The legislation of 1876 was practically based upon the decision of the committee of 1875.

The CHAIRMAN: It was thoroughly discussed there.

Mr. O'HARA: Yes, it was threshed out.

Mr. POPE: No, hardly threshed out; it was discussed.

The following evidence was then called:—

Mr. *Frederick John Evans*, examined by Mr. MICHAEL.

I am a civil engineer, and a member of the Institution of Civil Engineers. I have been connected with The Gaslight and Coke Company for more than forty years, and for many years had the management of the Goswell Road and Westminster stations. When I retired from the company's service I was the chief engineer. I am well acquainted with their system of purification. I designed and constructed the Beckton Gas-Works, which

are the largest in the world. They were constructed under the powers obtained by the company in 1868. I was selected by the Duke of Richmond, who was then the President of the Board of Trade, as one of the three Gas Referees to be appointed under the Act, on account of being practically skilled in the manufacture and distribution of gas. I held that appointment for eighteen months, but ultimately resigned, in consequence of being repeatedly attacked by the Metropolitan Board of Works, and by the Corporation of London, for not fixing the standard of purity as far as sulphur was concerned, and they used to make some very severe remarks, saying that I was prejudiced in favour of my own company. At last it became so unbearable that I sent in my resignation to the Board of Trade, but they declined to accept it. They said, "We will write to the Corporation, and very likely you will not be annoyed in this way." However, the annoyance went on, and I resigned again, but the Board of Trade still declined to accept my resignation, because they were so well satisfied with the way in which I performed my duties. Eventually, things became so bad that I insisted upon their accepting it, which they did in May, 1871, and sent me a very complimentary letter, regretting the cause of my having to resign. I was at that time the only member of the Board of Referees who had any practical acquaintance with gas manufacture. In 1872 I resigned my position as engineer-in-chief to the gas company. I was then elected to a seat on the board. There was a special clause in the company's Act of 1872, empowering me to be appointed as a director. The directors themselves had no power to appoint a director, as the board was filled up, but by that special clause I was appointed to act as a director, and I have so acted since. Since that time I have taken an active part in the affairs of the company, in the engineering and manufacturing departments. In the early period of gas manufacture lime was used for purification. The lime was mixed with water, put into a wet lime purifier, and the gas was allowed to bubble through the lime water, and this purified the gas from the carbonic acid and the sulphuretted hydrogen. The refuse water was at that early time—I am talking of 40 years ago—run into the sewers, and it got into the river, or we used to run it into the ground—in fact, we got rid of it as best we could. However, a stop was eventually put to that, and I think it was in the year 1825 that the complaints became so numerous that the Secretary of State of that date, I do not know who he was, appointed Sir William Congreve to investigate the gas company's works, and he found that this refuse lime—"blue billy," as it was termed then—was causing the nuisance, and he gave instructions, and recommended to the Secretary of State, that the whole of the works should be puddled round outside, which was done, but it effected very little good. After the gas had been passed through the milk of lime there were no other means adopted for purification. At that day we knew nothing about sulphur, and all we considered necessary was, that if the gas was free from sulphuretted hydrogen, it was practically free from any impurity. I believe at that time the presence of sulphur was very little known. I have a book here—Matthews's "History of Gas Lighting"—in which the presence of sulphide of carbon is distinctly denied by Dr. Dalton, and by John Thomas Cooper, the great gas chemist of that day. This was given in evidence before Parliament on the Westminster Oil Gas Bill in 1825. The chemists of that day did not believe in bisulphide of carbon, and said it did not exist. We said, "As long as the gas is free from sulphuretted hydrogen, it is quite good enough," and the public thought so too. Carbonic acid was not considered an impurity, but we took it out because we could not help it; if it took out the sulphuretted hydrogen we must take out the carbonic acid. After a time the company adopted another process; they allowed the "blue billy" to settle in the tanks, the solid matter fell to the bottom, and the thin liquid was evaporated under the ash-pits. The thick stuff was then burned in ovens, and used over again for purifying. The nuisance became so great that we, about 1840, adopted the dry lime process, which consisted simply in passing gas through a vessel containing lime in a sort of moist state—slack lime, in fact. This lime is placed upon trays, and the gas goes through it. The same amount of impurity is taken out—carbonic acid and sulphuretted hydrogen. A difficulty soon occurred, and that was the immense trouble

we had with the refuse lime. When I say that it took double the quantity to purify the same amount of gas with the dry lime process that it did with the wet, it will be seen that the quantity of lime we had to dispose of was very great indeed. Each ton of coal takes about a bushel of lime, or about 60lbs. There are 18 bushels to a cubic yard or ton, and a yard of lime when it is slaked produces two yards of slaked lime. We tried every plan we could think of. We used to ventilate it—that is to say, before the lime was taken out of the purifiers we used to drive atmospheric air down through the lime, and it went up a chimney. That was carried on some time, but the evil was not lessened, because it simply drove out the sulphuretted hydrogen from the lime. It went up the chimney and fell down in the neighbourhood, and a curious thing was—I am now talking about the Westminster station—that it used generally to fall down in Dean's Yard, and we used to have complaints from Dr. Buckland and other residents there. The Chartered Company were at that time indicted for a nuisance by the parish authorities. We used to convey the lime away in covered carts, but the informers used to follow the carts, and lay hold of them, and take them to the greenyard, and the contractors were taken before the magistrates and fined; but, independently of that, there was a great difficulty in getting rid of that refuse lime. An immense quantity of it was deposited in Belgravia; in all the roads and the fillings-in there are thousands and thousands of cubic yards which have been shot there; but at last that was shut against us, as Mr. Cubitt said, "I cannot have any more of this filth here." Then it was taken away into the country, and we had to pay as much as £1 a yard to cart it away, and what the end of it would have been I do not know—we must have shut up our works, I am afraid; but about the year 1840 we discovered that peroxide of iron, or hydrated peroxide of iron, could be used for purifying gas, and that it could be used over and over again without any nuisance whatever; no sulphuretted hydrogen was given off on exposure to the air. The sulphur that had been absorbed by the iron was thrown out again on exposure to the air, and was left in the material as pure sulphur. This material could perhaps be used for twelve months, and at the end of that time the material was sold at a profit, and we had no further trouble at all until within the last few years. It acted also in this way, that the sulphur kept continuously increasing in the purifying material until it became worth the while of manufacturers to extract it for the purpose of making sulphuric acid. We were in consequence enabled absolutely to sell it at a gain, and then have the material brought back again after the sulphur had been taken out. That method, which entirely superseded the use of lime as a purifier, continued in use up to the appointment of the Referees in 1868. The question of the sulphur in gas arose during the proceedings on the Act of 1860; but previous to that the attention of the public had been drawn to it by the late Dr. Letheby in 1854 or in 1852, I do not know which. He exhibited before the Court of Sewers a little bottle containing oil of vitriol, saying he had obtained it from the combustion of 100 feet of gas burning in a room. The Court of Sewers were astonished at it, the papers got hold of it, and it was shown that this destructive compound would very soon, as he stated, destroy not only the atmosphere, but destroy life, destroy furniture, and in fact would destroy everything. At that time there was a denial in the scientific world as to the bad effects of sulphur in gas, and also as to the production of sulphuric acid. I should, however, tell you that when Dr. Letheby and other people at that time were condemning the gas companies for making such impure gas and destroying everything—when he got these 21 grains of oil of vitriol in 100 feet of gas—that that 20 grains only represented 7 grains of sulphur, which shows how little he knew of it; and yet when the Act of 1860 was passed, it was only by Dr. Letheby showing that, the 20 grains of sulphur, which really represent 60 grains of oil of vitriol, was inserted. In the Act of 1860 there was no prescribed mode of ascertaining the quantity of sulphur in the gas, nor was there any apparatus defined; but there were heavy penalties for non-compliance with the Act, I think amounting to £20 a day.

Mr. MICHAEL: You will find that the 25th section of the Act of 1860 is, "The quality of common gas supplied by any gas company shall be, with

respect to its illuminating power at a distance, as near as may be, of 1000 yards from the works, such as to produce from an Argand burner, having 15 holes and a 7-inch chimney, consuming five cubic feet of gas an hour, a light equal in intensity to the light produced by not less than 12 sperm candles of six to the pound, each burning 120 grains an hour; and the quality of cannel gas supplied by any gas company shall, with respect to its illuminating power at the distance aforesaid, be such as to produce from a bat's-wing or fishtail burner, consuming five feet of gas per hour, a light equal in intensity to 20 such sperm candles; and each such gas shall, with respect to its purity, be so far free from ammonia and sulphuretted hydrogen that it shall not discolour either turmeric paper or paper imbued with acetate or carbonate of lead, when those tests are exposed to a current of gas issuing for one minute under a pressure of five-tenths of an inch of water, and shall not contain more than 20 grains of sulphur in any form in 100 cubic feet of gas: Provided that any gas company, and the local authorities of the district supplied by such company, shall be at liberty to agree upon any other or different test by which to ascertain the purity of the gas, or to vary the amounts of ammonia or sulphur in any form hereinbefore allowed, and thereupon the company shall be thenceforth liable to have the purity of their gas tested in the manner so prescribed." Then comes the 26th section, which prescribes the penalties: "If the gas supplied by the gas company be at any time of less illuminating power or of less purity than according to this Act it ought to be, the gas company shall for every such offence, on a summary conviction before a police magistrate, forfeit a sum not exceeding £50, and also, in addition to that penalty, and whether that penalty be recovered or not, a further sum of £10 for every day after notice in writing from the local authority during which the offence continues: Provided that such police magistrate shall not convict under this section, if it shall be proved to his satisfaction that such defect of gas was occasioned by any unavoidable cause or accident." Now those [pointing to a model] are little bits of bibulous paper wetted with acetate of lead in order to determine whether or not sulphuretted hydrogen is present in the gas.

Witness: Yes. We ordinarily employ such apparatus, which is continuously in action, in order to show day by day whether sulphuretted hydrogen has been present in the gas or not. If it is present, it causes the bibulous paper so wetted to become brown or black. We keep a register of those pieces of paper every day; but a similar apparatus is used at the testing-places by the testing chemists.

The CHAIRMAN: Are we concerned with this part of the case—sulphuretted hydrogen?

Mr. MICHAEL: Only as it bears upon the question of the sulphur. I think we may take it generally that all the metropolitan gas is absolutely free from sulphuretted hydrogen. I do not think any question will arise upon that.

Examination resumed: The provisions of the Act of 1860 were never carried into effect at all. There was never a case in which a company—although they were constantly infringing the amount of 20 grains—were convicted.

Mr. MICHAEL: In fact, was anything whatever done by the gas companies to diminish the quantity of sulphur which was left in the gas after it had been purified by the oxide of iron?

Witness: I think not; as far as my own company were concerned, that was so.

Have you any means of knowing how the quantity of 20 grains in the Act of 1860 was arrived at?—That was done by an apparatus called Dr. Letheby's apparatus. It consisted in burning the gas in a trumpet tube, and the products of combustion were condensed in a glass cylinder; instead of an upright thing, it went into a cylinder like that [pointing to a model], and the products of combustion with the water that was formed fell to the bottom. Those products were afterwards taken away and operated upon, and the amount of sulphur contained in the gas was ascertained.

Have you been able subsequently to determine whether or no the apparatus that was then devised really gave an accurate representation of the

quantity of sulphur contained in the gas?—No; it did not. The difference of Dr. Letheby's apparatus and that apparatus was equal to about 8 grains in 20—that is, 20 grains would be made into 28 grains by that apparatus.

It was not the fact, therefore, that the cylinder was diminished in size in order to prove a smaller quantity of sulphur, but in reality to prove a larger amount of sulphur?—Yes.

It was not that a larger cylinder gave a larger quantity of sulphur than ought to be represented, but in truth it gave a smaller quantity than the actual quantity present?—Yes.

By the use of that cylinder you get a more accurate representation of the total quantity of sulphur, other than sulphuretted hydrogen, contained in the gas?—Yes. I may say that the Referees, when they first fitted up the testing-stations, had a large cylinder, but the result obtained was not to be depended upon at all; they then put a small cylinder, about four inches in diameter, and that gave a better result, but the amount was so uncertain that the thing was not to be relied upon at all; and then we contrived the apparatus which has been used ever since. I do not say that that gives the full amount; but at any rate there is more uniformity in its results, and it gives a very fair average; and one thing in its favour is that it is so easily worked, that it requires no skill, labour, or special talents.

The CHAIRMAN: Perhaps I might interrupt you for a moment, but I do not know what this evidence is leading up to.

Mr. MICHAEL: This is giving you the history of legislation with respect to sulphur, and to show under what circumstances the limit of 20 grains was fixed.

The CHAIRMAN: Is your contention that 20 grains ascertained by the old process is more than 20 grains under the modern one?

Mr. MICHAEL: 20 grains under the old process really represented 27 grains, if correctly determined; the quantity ought to be according to the experiments, not put at 20 grains, but at 27 or 28 grains.

Witness: It also shows this, that the public, while they were thinking they were only burning 20 grains, were really burning 28 grains, and made no complaint.

Therefore, we may fairly assume, if the apparatus had been as perfect then as it is now, that 27 or 28 grains would have been put in the Act instead of 20 grains?—Yes, I think so.

The CHAIRMAN: You say, in fact, that it was 27; your contention is that practically it was 27 grains?

Mr. MICHAEL: Only, having that error, it was put in at 20 grains, when it was intended to be 27 or 28 grains.

The CHAIRMAN: That does not follow.

Mr. MICHAEL: I can only put the case in the best way possible. When we have to go back 17 years it is very difficult to define what was in the minds of the committee or the Legislature.

The COMMITTEE: It is not a question of "mind," is it? Your contention is that the Act prescribed a limit of 20 grains, according to the apparatus then used, while the new apparatus limited it to 27 grains.

Mr. MICHAEL: Quite so. (To witness:) Dr. Letheby gave evidence very frequently with respect to the sulphur question in gas Bills, did he not?

Witness: Yes; he was the great authority.

Mr. MICHAEL: Did he not constantly say there were no known means of eliminating the sulphur from the gas?

Mr. O'HARA: You must produce that if Dr. Letheby said so. If you have any treatise of Dr. Letheby's you may produce it, but do not give your views of what Dr. Letheby said.

Witness: You have the notes of his evidence there.

Mr. O'HARA: Then my learned friend can use them, but I do not want your remarks on that.

Examination resumed: In 1868 the sulphur question came before Parliament again, but the committee felt there was not sufficient information for them to determine, or for them to fix an amount of sulphur, and they thought the best plan would be to appoint three gentlemen as Referees, who were to investigate the question, and they were then to determine

what the amount should be, carrying out that clause in the Act which says that they are to act with all due regard to a nuisance not being created. Practically it comes to this, that there was no fixed limit put in the Act of 1868. I was one of those Referees, and there were two other gentlemen appointed, who were not specially acquainted with the process of gas manufacture. The Referees investigated the various modes with reference to the sulphur question. Our first endeavour was to devise means for testing the illuminating power of the gas; and that apparatus is now in use. My colleagues were Mr. R. H. Patterson and Mr. Pierce. We investigated the question of the sulphur, and I showed them all the experiments, and also what our duties were, and how the sulphur could be taken out. When they applied to me to know whether I could not fix a standard, I said, "No, I cannot, if I conscientiously carry out that Act of Parliament. I am not in a position to determine any amount of sulphur. There is only one mode of reducing the amount of sulphur, and that is by the use of lime." I then told them that that always created a nuisance, I showed them the lime, and everything else, and said I could not recommend a thing which I knew would be a nuisance to the neighbourhood, and a nuisance to the public generally.

Mr. MICHAEL: What did that eventuate in on the part of the Referees—what was the plan you adopted?.

Witness: There was nothing done during all the time that I was a Referee. I never could fix the maximum amount of sulphur; the other Referees felt with me that it would be a very great hardship upon the companies to fix a standard, having regard to that clause in the Act of Parliament.

I think you recorded the amount of sulphur?—We did; we gave orders that the amount of sulphur, as tested by this apparatus, should be simply recorded; the object of that was to see whether the amount of sulphur in the gas was uniform, or whether it went up and down with fits and starts. In fact, we wished to see exactly what took place under this new state of things. I left after 18 months, for the reasons I have given, and I think the Referees themselves, after I had left, were till 1872 before they fixed the standard. When I resigned, Dr. Pole, one of the present Referees, was appointed in my place. In 1872 the places of Mr. Patterson and Mr. Pierce were filled by Professor Tyndall and Mr. Vernon Harcourt. Those gentlemen had a knowledge as chemists, but I do not think they had a practical knowledge of the manufacture of gas. I do not think, if they had known all the circumstances of the gas companies at the present time, they would have fixed 15 or even 25 grains. We made some very extensive and expensive experiments upon a plan originated by Mr. Harcourt, costing upwards of £1500, but up to the present time no practical mode has been devised, without the use of lime, by which the amount of sulphur in gas may be limited. The Referees decreased the maximum amount of sulphur to be allowed, so far as Bow, Bromley, and Beckton were concerned, which obliged us to use an increased quantity of lime. Up to that time we had in some cases used lime in conjunction with oxide of iron, to take out the carbonic acid. From that combined process no nuisance resulted, but owing to the more stringent regulations of the Referees we were obliged to increase the quantity of lime used for the purpose of reducing the sulphur compounds, the result being that we brought down the amount of sulphur to the requirements of the Referees. There was no difficulty; I knew all along that lime would do it, but I always objected to the use of lime, on account of the nuisance it occasioned, and not only the nuisance, but the difficulty of getting rid of the refuse lime. The use of oxide of iron was, therefore, discontinued altogether, and lime substituted in its place, which is a retrograde movement altogether—it is a reflection upon science. We were actually in 1875 going back to the old time of 40 or 50 years ago, when the directors at that time saw the nuisance and ceased to use it; they abandoned it, and now we are compelled to go back to it again.

The COMMITTEE: The two processes are combined, are they not; you use both?

Witness: We should, if we were allowed to go back to the oxide of iron again, use a little for the carbonic acid.

Mr. MICHAEL: I do not think you have quite apprehended the honourable member's question; do you at the present time use oxide of iron with lime?

Witness: No; we are obliged to give up altogether the use of oxide of iron, and revert to the process of lime simply, in consequence of the restrictions put upon us by the Referees.

But before that you had used the combined process of oxide of iron as a purifying medium, with a small quantity of lime, which, as I understand you, created no nuisance, in order to get rid of the carbonic acid, which deteriorated the illuminating power of the gas?—Yes.

I also believe there are some injurious effects, which are hardly well ascertained to be due to the excess of carbon in the gas burnt?—I do not know anything about that.

Did you make any representations to the Referees, asking them to reconsider the determination at which they had arrived with respect to the amount of sulphur?—Yes, we did repeatedly; and in the result the Referees said, "We think you can do it; we think you are not using sufficient care, and we shall not alter our maximum."

Do they inspect your various stations?—Yes.

Have they ever pointed out to you any processes which you might adopt, and which you have refused to adopt?—No; we have adopted everything they have suggested.

Has it eventuated in this, that in adopting this process, and reverting to the use of lime, you are constantly told that you are creating a nuisance?—That is so.

Will you explain to the committee, as shortly, but as fully, as you can, how that nuisance arises?—The lime, after it has purified the gas, is combined with all the sulphuretted hydrogen, and some of the sulphur compounds, and it forms a sulphide of calcium; that lime, when it is taken out of the purifiers and exposed to the air, or the oxygen in the air, throws off all the sulphuretted hydrogen that has been formerly absorbed by the lime, and it goes into the atmosphere, and causes these complaints. We take every possible care—the purifiers are covered up, the waggons are covered up, the barges are covered up, and still you cannot prevent this emanation of sulphuretted hydrogen. I was on Saturday with Mr. Pope down at Fulham; every care was being taken, but there was no mistake about the smell. I put a bit of acetate of lead paper no my hat; it did not go black, but it got brown, showing the presence of sulphuretted hydrogen.

First, have you used an excess of care, and all means at your disposal, to prevent the production of sulphuretted hydrogen in the air when you have the lime removed from the purifiers?—I believe every possible care is taken by our engineers, but we cannot prevent a nuisance being created. The total quantity of lime in a year we have taken from our various works is about 100,000 cubic yards—about enough to fill up 8 or 9 acres of land 6 feet deep. There is great difficulty in disposing of it; it has all to be taken down to Beckton. There are 150 acres of ground there, but in time all that will be filled up, and where we shall have to go then I do not know. We have been continually threatened with injunctions, and complaints have constantly arisen, owing to the nuisance created by the removal of the lime. There are the Fulham works, about which there have been complaints; and there are the Bromley works, and several other stations where there are great complaints—at Shoreditch and at St. Pancras—in fact, where the lime is used, it is a nuisance, and you cannot get over it.

Supposing oxide of iron, and the small quantity of lime which you represented, were again to be reverted to, would there be such an amount of sulphur left in the gas as to occasion any injury either to life, health, or property?—Certainly not; it is perfectly absurd about that question of sulphur; and before I have done I think I shall be able to show the committee the absurdity of the sulphuric acid question and the whole of the sulphur question altogether. If it were not so serious to the companies, this question of the sulphur in gas would be simply ridiculous, because the quantity is so small that if it was deposited in the way that we have heard stated in this room it would have no injurious effect; but I contend that sulphuric acid could not be formed, and is not formed, and I will show

that by experiment. I have practically studied this question, and looked at its effect as gas is ordinarily burnt in rooms.

Have you endeavoured to find out whether any of these alleged disastrous consequences result under any circumstances from the ordinary burning of gas?—It is perfectly ridiculous. That picture [pointing] I have had for 25 years; and, according to the theories we have heard, it ought to have been utterly destroyed by the oil of vitriol. It was hung in my dining-room. It is true the ventilation is very good—there is ventilation into the chimney. That [pointing to another picture] I have not had so long; I have had it eight or nine years. That has been in a hall 16 feet by 12 feet; but there is a gas-stove in it, and I burn that gas-stove all through the winter; and there is a gaslight as well, but no one would ever say that the painting is injured, or the gilding injured.

Have you ever found these crystals of sulphate of copper and sulphate of zinc deposited from the burning of the gas?—No; it is rubbish; certainly not. We have heard that cordage was affected most tremendously by sulphuric acid. I took a bit of this cord [produced], and wetted it with a little distilled water, and I certainly did expect that there would be an acid action, but it was alkaline. There is the cord there, and anybody may try it if he likes. I should tell you that that picture has been in other rooms under not such good circumstances for 25 years. In that room there were 400,000 cubic feet of gas burnt. According to the theory, supposing you had 30 grains of sulphur in 100 cubic feet of gas, that 30 grains ought to have produced something like 90 grains of oil of vitriol, and during that time I should have had between 15lbs. and 16lbs. of oil of vitriol in the room in which that picture has been hanging. It ought to have been running down, and there ought not to have been a piece of the painting left. The principal nuisance, I believe, derived from gas is from the bad ventilation, nothing else. I will show you again the absurdity of this sulphur question. Take 100 cubic feet of gas, which will produce 75 cubic feet of carbonic acid, it will produce about 200 cubic feet of vapour of water, and about 100 grains of sulphuric acid in the room in which that picture was, which is about 5300 cubic feet capacity. You have a proportion of carbonic acid of 1 in 46. I will assume if all the products of an evening, say of seven hours, are put into the room at once, in that case you would have 1 in 46 of carbonic acid, and 1 in 60,000 of sulphurous acid. Now, sulphurous acid and carbonic acid are equally fatal to life; the one is as much a poison as the other. I have tried it on rats, and things of that sort. If you take carbonic acid and put a rat in it, it goes dead instantly, and the same takes place if he is put into sulphurous acid; so that really the absurdity is this, that you are actually dealing with a thing which only contains 1-60,000th part—that is assuming that there is no ventilation; but if you have good ventilation, it amounts to one part in 5,000,000. You have to deal with that and the carbonic acid, which exists to the extent of 1 in 46. Whoever heard of the explosion of a coal mine taking place, in which the men were killed by sulphurous acid? It is always the carbonic acid which kills them.

There is a large quantity of carbonic acid, no doubt, and there is a great deal of discomfort where there is no ventilation in a room in which gas is burnt?—That is the cause of annoyance.

You have very heated and very dry air?—Yes; and you get an oppressive feeling from the want of oxygen.

I think you have tried an experiment as to turning on the gas and not burning it in a room?—Yes. I gave that evidence in favour of the Metropolitan Board in their Subway Bill; it was a question of ventilation in a subway. I went home one evening from the committee on that Bill about four o'clock, and the gas was alight. I turned off one of the burners and then turned it on again. My wife and other people were there, and they never smelt the gas. They went to bed at half-past ten, and I said, "That is a capital experiment." This burner had been escaping all the time, and they had never smelt it, which shows that all the products of combustion were being taken away, and therefore if any sulphurous acid was formed it was taken away directly. But I go further, and say that sulphuric acid is not, and cannot be, formed. I will show that to you directly.

The COMMITTEE: Is this sulphuric acid formed in any way before combustion takes place?

Witness: No, afterwards.

You say you did not ignite the gas?—That was for a different object—viz., to show the amount of ventilation; it was allowing the pure gas to escape. Of course, it was not burnt. We should have smelt it directly if the ventilation had not been there?

Mr. MICHAEL: At the same time also, if there be any injurious effects from the gas, you have the carbonic acid in the carbon compounds to account for it, and you have the heated and dried air, totally irrespective of the question of sulphur?

Witness: Yes.

I ask you again, have you in the course of your investigations, seen anything to prove that there is any deposit, either of free sulphuric acid or sulphuric acid in compound with metals, deposited from the use of gas?—No. You have got a certain proof. Nothing can be stronger than that picture. It is true you may bring some specimens which have got some damage, but I believe it arises then from other causes.

May I put it to you in this way: If it be good to take away all the sulphur except 15 grains, it would be better to take it away altogether?—That we cannot do.

There are no known means by which the whole of the sulphur could be taken away?—No. You may use lime to any extent, and there is something like 8 or 10 grains of sulphur that you cannot take out.

And if you do, you could not use the gas, as it would not be odorous?—I do not think the odour of unburnt gas is due to any sulphur; it is the natural odour of the hydrocarbon.

I believe the Bill of 1875, which was introduced by the Corporation and the Metropolitan Board of Works jointly, contained no provision whatever as to sulphur?—No, and they were perfectly right—they knew the absurdity of it; they had some eminent chemists to advise them, and they said, "Do not have anything to do with it, it is perfectly absurd;" and they acted upon that advice.

That was a Bill by which it was intended to lodge the supply of gas in those two bodies?—Yes.

Can there be any reason why, if it were requisite to put restrictions on a company, that those restrictions ought not to apply to the Corporation or the Metropolitan Board of Works?—If they thought that the sulphur was a matter of any moment, they were bound to have put the clause in; but they thought it was of no moment whatever.

The COMMITTEE: What was the company you are referring to?

Witness: It was not a company; it was the Corporation and the Metropolitan Board of Works. They brought in a Bill to make their own gas.

Mr. MICHAEL: That Bill contained no clauses with respect to sulphur purification?

Witness: None whatever.

Had this question of nuisance anything to do with the removal of the company's stations into the country?—Oh, yes; in fact, it was one of the great motives of our going to Parliament to enable us to get to Beckton. The complaints which were made at the Westminster station and the City Gas-Works at Blackfriars, and other stations, rendered it desirable to go away; and the result has been that we have disbanded four stations for the manufacture of gas, simply on account of the nuisance that resulted from keeping the lime in those populous districts.

Examination continued: At the present time, at the various stations where we are obliged to employ lime, the same nuisance is continually arising, and will be, so long as lime is employed for that purpose. I wish to explain to the committee that it is almost impossible to get sulphuric acid by the combustion of gas. [Witness explained some apparatus and made some experiments in illustration of his statement.]

By the COMMITTEE: We all admit that sulphurous acid is produced; but the argument is that it turns into sulphuric acid, and destroys all your articles.

Mr. MICHAEL: You have been now showing the committee experiments of gas burnt under circumstances which are totally diverse from the cir-

cumstances which prevail in the ordinary combustion of gas, but even where you have put it under most favourable circumstances, as is shown by the least cloudy bottle, you fail to produce anything but a very small quantity of sulphuric acid?

Witness: That is so.

When you get ammonia present, you put it under different circumstances, and you get a very much larger quantity of sulphuric acid; and, therefore, if there be a quantity of sulphur in the gas, and you have this apparatus in which to burn it, and you have ammonia present, that sulphuric acid may be found?—Yes.

Without that, under ordinary circumstances, no sulphuric acid is found?—No.

Therefore the laboratory experiments you have for determining the quantity of sulphur tell you nothing as to the ordinary circumstances of burning gas in the open air or in the air of an apartment?—Quite so.

You have to prepare something particular in order to produce sulphuric acid, and even then, unless you have got ammonia, it is a very minute quantity?—A mere bagatelle.

Does it not come back to the general question: Is there any sulphuric acid found under ordinary circumstances at all injurious to health, or life, or property?—Most certainly not.

Cross-examined by Mr. O'HARA: I am not a professional chemist, but I know enough of the chemistry of gas lighting to suit my purpose. I am not aware that Mr. Patterson made any discoveries which improved the process of gas-making materially. I have heard of what is called Mr. Patterson's process, and I do not say it is not a desirable process; but I say it is not his process, because it existed ever since lime was used for purification. Mr. Patterson, from his want of practical knowledge of what had been done years ago, thought he had discovered something new.

Mr. O'HARA: At all events, he did think, and other people thought, that he had discovered a new process?

Witness: I never thought so.

You have got your own views upon these matters. Is Mr. Patterson conducting or carrying on a lawsuit, which is now in the House of Lords, about this very process?—Yes; he is appealing from the Court of Appeal.

Therefore, as far as Mr. Patterson's process is a new one or not, the decision of the ultimate question has not been arrived at?—It has not.

In the meantime, you have decided the question in the way you have just told the committee?—In my own opinion, certainly.

You have decided some other things. You have decided that the presence of sulphur in the gas is all a delusion—I mean the hurtful influence of it?—I state nothing but facts. It is not a question of science at all; it is a question of fact, and I contend that if the statements made of the amount of sulphur and its injurious effects are true, it did not want a scientific man to decide it. Any gentleman who has books or pictures can himself tell whether they are destroyed or not.

Do you contend that the question of the presence of a certain amount of sulphur impurity in gas is a delusion in the public mind—the hurtful effects of it?—Certainly, I do.

Had you, between 1869 and 1870, prescribed any limits of impurity as to the sulphur in the gas?—No.

You said that the Metropolitan Board of Works and the Corporation said such things of you that it made your position quite unpleasant; was there any pressure on the part of the public with reference to the non-prescribing of the maximum impurity?—They said so; but the company did not find that their customers complained to them about it. You would think if a man is complaining about his meat being bad, or his wine being bad, he would not go to a person of any other trade; he would go to the man who supplied him with it.

Let me put a hypothetical case. Supposing a man had a house steward, do you not think he would make a representation to him, and not bother himself about running after the butcher, the baker, the tinker, and the candlestick-maker?—We have got many thousands of consumers, and I tell you we never had any complaints from them of the badness of the gas.

We know no difference now when the gas is at 30 grains from what it was when it was 30 to 40. The public cannot appreciate it, they know nothing at all about it.

Therefore, you think they ought to have no protection of this kind provided?—I say it is unnecessary, and that all these injurious effects are a delusion, and do not exist; and I believe this, that if the committees in 1860 and in 1868 had had the question put before them in a practical and proper way, they never would have passed 20 grains.

You think that honourable members who are sitting here, if they had had the thing put practically and properly before them, would have arrived at a different decision about the purity of the gas of the Crystal Palace Company?—They might take a very different view from this. I cannot know what is in their minds. I hope they will take a different view in this case, that is all.

Cross-examination continued: In 1860 the Chartered Company made a great fight against the 20 grains which were then put in the Act, but at that time we did not know as much as we do now. In 1868 the great struggle of 1866 and 1867 ended in the passing of the City of London Gas Act. During those years we showed the committee that the knowledge of the amount of sulphur, and of the sulphur question altogether, was very much in the dark. I do not know whether the committee recommended it, or whether we suggested it; but, at any rate, the difficulty was got over by having Referees appointed, but no maximum was fixed by Parliament. I remember the inquiry before Mr. Forster's committee, when it was agreed that the Referees were to remain just as they are now. We did not make a fuss about the purity clause in 1875, because the Referees had not fixed the maximum so low as it is now; and secondly, we had not had experience of the use of lime to the extent we have at present. As soon as we found we could not do it without creating a nuisance, we asked the Referees to allow us a little more sulphur, which they did not do, and that is the reason we are here.

Mr. O'Hara: Last year, when you came to Parliament for a Bill, you inserted that clause in the Bill—it was your own Bill. The Metropolitan Board and the Corporation had a fight with you in Parliament in 1875, and, consequently, in 1876 this Bill was practically your own Bill?

Witness: Quite so.

It was a Bill to be assented to by the Metropolitan Board of Works and the Corporation, as fixing for a definite period the gas question. Do you remember Mr. Burke stating in evidence, in 1875, that all he wanted was finality in this matter?—Yes. Having got what you call finality——

Mr. Pope: That was as regards dividend and money. I do not think Mr. Burke entered into the purity question.

Mr. O'Hara: I think Mr. Burke said, "We shall be very happy to give you this, that, and the other, if you will only let us alone."

Cross-examination resumed: We do not wish to disturb the Act of last year; we only want to repeal two clauses, because they press very harshly against the company.

Mr. O'Hara: Did you intend this settlement last year to be a final settlement, or did you not?

Witness: You cannot tell. Certain things have taken place since then; the maximum has been increased, and the difficulties have been increased. We have amalgamated with the Imperial Company, and the difficulty of getting rid of this refuse lime has now become so great; and that alone, even if there were no nuisance, would be sufficient for the repeal of the Act in that respect.

At what period did your directors resolve to come for this alteration of the law?—I think just before the time that we could give notices. In October.

About the 11th of August, 1876, the settlement or compact between the Metropolitan Board of Works, the Corporation, and The Gaslight and Coke Company had been finally sealed with the Queen's Assent, but within three months of that you made up your minds to come to Parliament to disturb it?—Yes.

Did you in last session make an alteration in the clause that prescribed the penalty for impurity in the supply of gas?—An alteration was made.

We showed that it was not fair to take one day, and three days were allowed us.

Why did you not, when you asked to have the law changed in that respect, make those representations that you do now?—Simply because the full effect of this lime question had not been felt; and it has not fully come into operation yet.

Have the Referees, since the passing of the Act, altered the maximum impurity for sulphur compounds?—Certainly not since last year.

Notwithstanding that, you think it right to come to Parliament to ask for an alteration in your Act?—Certainly; because we begin to find that the restrictions placed upon us of the 13 grains, and all that, have necessitated an alteration in our apparatus. We have had to spend a very large sum of money—over £100,000—in new purifiers, in order to meet that. The effect of the alteration and the increased amount of lime was only begun to be felt last year.

Do you say that it was felt between the 11th of August and October?—And before that too.

If it was felt before that, why did not you ask to have a change made in the Act of Parliament?—Because the matter was left to the Referees, and we thought that, taking all the circumstances into consideration, they would then give such a maximum as we could honestly carry out without the use of lime.

The maximum prescribed by the Referees then was the same maximum as is prescribed now?—I am perfectly aware of that, but I gave you a reason why; in order to meet that maximum we had to lay out an immense sum of money to make these purifiers. They take one or two years to make, and they are only now coming fully into operation, but we find that using those purifiers with lime involves such a nuisance that we come here for relief, because the Referees will not give it us. If the Referees had met us and said, "We think there is something in what you say——"

The COMMITTEE: I do not understand what your evidence is; as to the requirements of the Referees before last August, what was the purity that they exacted from you previous to August last year?

Witness: 20 and 25, and 15 and 20 grains, the same as now. We have complied with their request as far as we could. Sometimes we ran up a long way, but when the gas examiner came we explained it to him. The great inconvenience we suffered from complying with the order was that we were obliged to use lime to a larger extent. The amount fixed, 15 and 20, and 20 and 25 grains, necessitates the use of lime, which causes a great nuisance. We have experienced greater difficulty since last August because the quantity of gas we have to make is now very largely increased, and, in addition to that, we are using a much larger quantity of lime; whereas, in the way we did it before, we managed to keep it down. Another thing is, that, although they fixed that maximum, we were very often above it, and we could not comply with it. We have never been charged or prosecuted under this clause. On several occasions Dr. Williamson has been down, and he has said, "Seeing the alterations you are making, so as to do away with any risk of going up above the standard, I shall report that you are doing what you can, and I shall recommend you not to be fined." Dr. Williamson is the Chief Gas Examiner.

Cross-examination resumed: In the year 1876 we used nearly 1,100,000 tons of coal, and of lime at the rate of a bushel for every ton.

Mr. O'HARA: Why have you given up the two processes of taking the sulphuretted hydrogen out by means of peroxide of iron and leaving the lime for the other sulphur compounds? Why have you divided the thing in two?

Witness: If you take out the sulphuretted hydrogen from the gas by oxide of iron, how are you to make the sulphide of calcium which acts upon the sulphur compounds? It is very likely that other people are of a different opinion to myself.

In 1867 Mr. Hawksley was asked: "If, therefore, there was a proposal for a new supply at a considerable distance from the inhabited districts, the sanitarian philosophers would not object, and we might have the advantage of using lime for the purification of gas?" His reply was:

" Certainly; but I think that a better mode has been discovered than has yet been spoken of, and that is to continue the use of oxide of iron for taking out the sulphuretted hydrogen, and then only using the lime for the purpose of taking out the remaining bisulphide. Now, that is not an offensive process. By the combination of the two processes, my opinion is that the works can be carried on where they are; but the effect of the double process is to incur the cost of about a penny per 1000 feet." What do you say to that? Is that a common practice?—I think Mr. Hawksley has been misreported there.

Let me go a little further, because Mr. Hawksley is here, and I had the advantage of asking him the question before I put it to you. He says he is very well reported. Let me ask you, is that process enunciated by Mr. Hawksley in that answer a common process now?—I am not aware of it. There are some works that are using oxide of iron and lime; but, as a rule, they generally use oxide of iron first. That takes out all the sulphuretted hydrogen, and therefore what is the use of passing the gas through the lime afterwards?

Supposing the lime was so arranged as to take out a portion of the sulphuretted hydrogen, would you still object to it?—That is a totally different thing, and I believe that is what Mr. Hawksley meant.

Suppose you give in your own way what Mr. Hawksley meant, and tell me whether that is a process that can be adopted?—It may be adopted, but still you are bothered with the difficulty of getting rid of the lime; you make much more offensive lime than it would be if the whole of the lime was used.

Cross-examination continued: We gave up using oxide of iron at Beckton four or five years ago, directly the agitation began about this question of sulphur. At Fulham our purifiers are in the open, and I should not advise them to be enclosed.

Mr. O'HARA: Do you think it is better to expose the contents to the wind, and so on, and so discharge them all over the district?

Witness: It is the getting rid of the lime. The lime is taken away in trucks in the open air, so that if the lime was taken out of a purifier which was in a room the exhalations must escape from the windows or openings, so that it is only a question of keeping it in the room for a little time. I do not see any advantage in that at all, and it is injurious to the men. If the Referees had allowed us a few more grains we should very likely have tried to get over the difficulty.

Having had your capital, price, illuminating power, and all those things settled, and everything out of the way, you thought it a good move to come to Parliament this year?—No; you quite mistake the thing. We we were acting under the Referees, and whatever they suggested we carried out. And we say, and have said all along, that if the Referees would only act conscientiously upon that clause in the Act of Parliament we should not have been here now.

The COMMITTEE: So far as the Referees have acted conscientiously, they were doing so before you obtained your Bill of last year.

Witness: We did not get to the extent of the nuisance.

When you got your Act of last year you foresaw that you would have an increase of business, and therefore you might have foreseen, whether you did or not, that the public would suffer to that extent from the nuisance?—We amalgamated with the Imperial and with the Independent Companies, and that brought us five more stations.

Still you took your Bill with that clause, and now you come to protect the public against your own Act of Parliament?—You may call it our own, but we say it is the Act of the Referees.

Cross-examination continued: There was a prosecution in connexion with the Bromley works for making a nuisance by the smell of the purifying process, instituted by the West Ham Local Board. There is no way in which we can dispose of this refuse lime to the farmers; the quantity is so large, and the difficulty we meet with in railway trucks so great—in fact, the railway companies will not take it. We shall have a witness here to prove the result of a railway truck being unloaded. It made the people ill. At present there is no difficulty in getting rid of it. We have got this large amount of ground, and we put it there; but in the course

of a year or two that will be filled up, and then we shall not know where to go. Another thing is that the farmers do not care about it. We had better put it on our own ground than go to the expense of carriage for taking it away. We do all we can—we give it away; some of the farmers do take a few loads away in the course of the year, but it is not used extensively, and that is the whole question. In country gas-works there is no difficulty; a railway truck would last perhaps a month or two months.

Mr. O'HARA: This lime, affected in this way, if exposed to the air, becomes pure after a certain time, does it not?

Witness; It has not so much smell.

In fact, it becomes innoxious after a little time. Now, the Bromley-by-Bow prosecution, how did that eventuate—did you get a dismissal, or were you condemned?—I think it was decided in our favour.

It was held that you made no nuisance?—Yes.

Re-examined by Mr. POPE: On March 31, 1874, the Gas Referees reduced the standard to its present point; before that it was 20 grains in summer at Beckton, Bow, and Bromley, and 25 at the other works—that would be in September, 1874. The order in March, 1872, was 5 grains more, and the next order, on Sept. 30, 1874, reduced to the present maximum. After August, 1876, complaints were made by the Shoreditch Vestry and the inhabitants of St. George's Square. In consequence of that, before November, 1876, application was made to the Referees to alter the standard of impurity. Finding they did not alter the standard of impurity, we gave notice for this Bill. During the whole of the winter those negotiations with the Referees were continued with a view to induce them to give us the relief sought for, but they were unsuccessful. If they had been successful we should have withdrawn our Bill. In August, 1876, the matter was left with the Referees exactly as it had been before. It is not of the Referees personally that I complain, but the fact that they have formed a view which seems to me not only inconvenient to the public, but unjust to ourselves, and that is the reason we are asking Parliament to rectify it.

By the COMMITTEE: I was present here during the hearing of the former case, and heard the evidence of Mr. Loam, of Nottingham. He said there had been some demand for gas refuse from the small farmers in the district. We could not send ours down the river to the Essex marshes, because the agriculturists there would not take it. We advertise it in the public papers, but the quantity is so enormous that we cannot get rid of it. With small works there is no difficulty, but when you come to treat of such enormous quantities as we have to deal with, there is considerable difficulty. I heard Professor Barff's evidence about finding sulphuric acid as a fact, but I have tried all my life to produce it, and cannot do so. This is evidence that my statement is correct. [Referring to one of the samples.] That ought to be covered with acid, and I say the same about books. The effect on the books, I believe, is entirely due to the moisture of hot air. Any one who could produce sulphuric acid by exposing sulphurous acid to the air would make an enormous fortune. The sulphuric acid makers would give anything if it could be done.

The COMMITTEE: Suppose, as a matter of fact, there were books in a library in which gas had been burnt, and they had remained on the shelves of that library for some years, and that afterwards a chemist, by washing them, did get off a solution in which sulphuric acid was present, then what should you think?

Witness: I should think very likely it came from the paste. All paste contains alum. I have got three books which were on a shelf alongside a number of other books, and those three books only were attacked, the whole of the binding being destroyed.

Major-General *William Harrison Askwith*, examined by Mr. POPE.

I live in St. George's Square, but formerly resided at Waltham Abbey, where I was superintendent of the gunpowder factory. While resident there, in consequence of spent lime being brought from the gas-works, I became familiar with the character of the offensive smell it possessed. Latterly, myself and the other inhabitants of St. George's Square have

been very much annoyed with the smell proceeding from the gas-works at the top of the square.

Mr. Pope: Could you recognize, from your previous acquaintance with spent lime, whether it had any relation to the same sort of smell?

Witness: Exactly the same, and it has been a serious annoyance to the inhabitants, so much so that in November last Mr. Sclater-Booth, myself, and the other inhabitants, presented the following memorial to the company:—

St. George's Square, S.W., Nov. 23, 1876.

Sir,—We, the undersigned, inhabitants of St. George's Square, beg to call your attention to the very serious annoyance that we have received by the mismanagement of the company's Pimlico Gas-Works. In the course of last night lime purifiers were, we believe, opened, and quantities of most offensive gas allowed to escape. The smell caused by this was so great that people were awakened in the night by it; all of us, with our families and servants, have suffered more or less by the nuisance caused by the servants of the company. The smell complained of is not the usual smell, always more or less offensive, to be perceived on passing this station, or when the wind is in the east, but a far more concentrated and sickening smell. Some of us have repeatedly complained, both to the agent to the Square Trustees (Mr. Smith) and to the company's officers, of the state of things committed at this station. The events of last night have occurred several times before, and as we do not intend to allow our families and ourselves to be made sick, and our property depreciated, by the conduct complained of, unless we have at once some real and satisfactory assurance that this will never be repeated, we shall be compelled to apply to the Court of Chancery for an injunction.

We are, Sir, your obedient servants,

C. Sclater-Booth,

(Signed also by 28 other principal inhabitants of the Square.)

J. O. Phillips, Esq., Secretary.

There is a general complaint about the smell, which was stronger during last winter than during the year before, although it has always been very bad.

Mr. Pope: Is it the general feeling of the inhabitants of the neighbourhood that this really is a substantial nuisance, of which complaint is justifiable?

Witness: In all my communications with them I have understood that it is considered to be a decided nuisance.

Cross-examined by Mr. O'Hara: I have been living in St. George's Square since March, 1868, and the smell has been always very bad. I cannot exactly say when I first made a representation of the unpleasantness to the gas company, but on several occasions during the last three or four years I have done so to the manager of the gas-works; to Mr. Smith, who is agent for Cubitt's people; and to Mr. Dines, from whom I purchased my house. We should have been glad if we could have got rid of the gas-works altogether. I was not aware at that time in what manner it was caused, although I am now aware of it. I was the author of the memorial, and took it round myself for signature.

Mr. O'Hara: Did you ever threaten the gas company that you would indict them, or anything of that sort?

Witness: No; it was mentioned by Mr. Dines, in the course of conversation, that we should do so if we got no redress.

By the Committee: We received a very civil reply from the company, relative to the Act of Parliament which appointed three Referees, stating also that the gas was to be of a certain purity, and that the Referees did not seem inclined to make any alteration relative to the purity of the gas, and therefore they were bound to use lime for the purification of it. We had made a previous application, and I had a note from Mr. Phillips, the secretary of the gas company, as follows:

The Gaslight and Coke Company, Secretary's Road, Westminster, S.W., Oct. 30, 1876.

Sir,—I regret very much to learn that you have suffered annoyance at the time our people at the company's Pimlico station were clearing out the lime purifiers.

The system of purification by means of lime now adopted in London gas-works has been forced upon us by a Government Board called the Gas Referees, with whom the directors are now in communication, with the hope of inducing them to permit some other mode of purification.

In the meantime, I have given the strictest instructions to the engineer, Mr. Hall, on the subject, and I beg to assure you that no pains shall be spared to prevent further inconvenience to your neighbourhood.

I am, Sir, &c.,

J. O. Phillips, Secretary.

Major-General Askwith, 119, St. George's Square.

I had verbally, and frequently, in the course of conversation with Mr. Dines and other people, made complaints about the nuisance for several years back; but the answer I received was that they themselves had represented it to the gas company, but could not get any alteration.

Mr. *George Dines*, examined by Mr. MICHAEL.

I was a builder in Grosvenor Road for many years, but have now retired from business. From 1833 to 1860, I was with the late Mr. Thomas Cubitt and his trustees. I was engaged on their behalf in very large building operations in South Belgravia. I have latterly, on my own account, built in St. George's Square, on a portion of their estate, a large number of houses, and have sold a great many of them. I own a considerable amount of house property there, and in the immediate neighbourhood. The houses in St. George's Square vary at the present moment from a rental of £160 a year to £600 or £700. I should think the average is £240 a year. The east side of the square abuts rather closely on to the works of the late Equitable Gas Company, which was absorbed into The Gaslight and Coke Company. I have known the gas-works for 40 years, and have been in the habit frequently of going through the works.

Mr. MICHAEL: How do you think they manage their works?

Mr. O'HARA: How does he know how gas-works are managed? Is he a gas engineer?

Mr. MICHAEL: Let us have his evidence, at any rate, for what it is worth.

Witness: They were kept very clean and nice, and things looked as if the place was kept as tidy as possible. I remember when the company purified by milk of lime. Thirty years ago, or rather more than that, the nuisance was something frightful on account of the stink. I cannot fix the exact time when that process was abandoned, and oxide of iron used in its place. The nuisance recommenced only a few years back, and there is a nuisance at the present time arising from the lime. I know the smell of sulphuretted hydrogen. I was in the neighbourhood last Friday; I am there every week. I went to the gas company's wharf to see what was being done there. I passed along in front of their works. When I got to the eastward of them—and the wind was blowing from the east—the smell was rather strong, so I thought I would go back, and I did so. The process of conveying the lime into the covered barges was going on, and the smell was very bad. It appeared that every precaution was then being taken to carry out the process without, if possible, creating a nuisance, and I saw the whole process. The purifiers were uncovered, and men were shovelling the stuff out into carts. When the cart was filled, it was covered with 3 inches of breeze or ashes, and was then taken out across the public road to their wharf on the banks of the Thames, where they had a barge with boards over it. A hole was cut in those boards, and a shoot was inserted which came up to the edge of the wharf. It was large enough to put the end of the cart in, and the front of it was covered over with a curtain or tarpauling, but that did not succeed in preventing a nuisance.

Cross-examined by Mr. O'HARA: I used to be a good deal about there when I was building my houses. I finished my last house about two years ago. The gas company get their coal in underneath by a tunnel.

Mr. O'HARA: Did it strike you at all that a tunnel would be a very good way of getting rid of that stuff, instead of bringing it across the public road?

Witness: Yes; they might do it in that way, by means of a barge, but exposing it is a nuisance. It is all over the place in a moment. It cannot be got rid of.

Do you not think that the longer you expose it the more likely is the smell to be offensive? Would you not rather that they tried to keep it underground as long as they could?—They would not let it rest when they got it underground.

Would you bring it across a public road if you could bring it underground?—Decidedly not.

Re-examined by Mr. MICHAEL: I believe that the greatest amount of nuisance is caused when the purifiers are opened and the lime emptied out into the carts.

Mr. MICHAEL: So that the nuisance was not in taking it along the road, but at the time of opening the purifiers and shooting the lime into the covered barge?

Witness: That was when the greatest amount of nuisance was occasioned. But the cart that had it in could be smelt for half a mile off. This is a map of St. George's Square, if the committee would like to see it [producing the same].

By the COMMITTEE: I have seen every brick laid on Eccleston Square. The houses there vary from £240 a year upwards; they are not double.

Sir *Edmund Hay Currie*, examined by Mr. MICHAEL.

I am a distiller, and chairman of the London Hospital. My distillery is situated on the Middlesex side of the river Lea—at Bromley—and my private residence is within 50 yards. I am very much annoyed by the smells from the gas-works. We have other smells, and plenty of them; but those are the worst that come from the gas-works. It is such an intolerable nuisance, that it makes my female servants ill; and the younger members of my brother's family, when they come to see me, are actually sick. I have traced that clearly and distinctly to the gas-works. I have made inquiries to satisfy myself that the gas company did all in their power to prevent the occurrence of the smells; and have always found the company very polite. They never refuse us admission at any time to see their premises. I should say that I have no knowledge whatever of the working of gas companies, and cannot give any information upon that subject, but I speak on behalf of 40,000 or 50,000 people who are suffering from the grievance. I have lived for 23 years in the East-end of London; I am the representative of the district at the School Board for London, and chairman of two or three hospitals, and know the feeling of the inhabitants thoroughly. I know all my neighbours very well. I have made myself acquainted with the circumstances under which this nuisance arises, and understand it is from being obliged to use the process of purification by lime, and we wish that system to be altered.

Cross-examined by Mr. O'HARA: We have been suffering from this nuisance ever since the Bromley Gas-Works were started, which was, I think, about two years ago. I ask the committee to do what they can to relieve my neighbours and myself from a nuisance which is as bad as anything can possibly be, and which renders life very uncomfortable there.

Mr. O'HARA: Let me call your attention to the section of the Act of Parliament the company seek to have repealed. [Section 36 read.] You see, Parliament has taken care of you already.

Witness: I do not see that it gives me any remedy there. What is it?

Mr. O'HARA: By indictment.

Mr. MICHAEL: That he had before.

Mr. O'HARA: Parliament has told the company that they must do a certain thing, but that they must not do it so as to become a nuisance.

Witness: Yes; I see that.

Supposing that this Act of Parliament saved your rights, and preserved you from the nuisance, would not that be satisfactory to you?—I do not quite follow you. My difficulty is that you say I may indict this company. That will cost me a great deal of money. I do not see why I am obliged to do anything of the kind.

You have got 40,000 or 50,000 sympathizers?—But they are poor people.

One shilling each from them would go some way?—Yes; but we have not many shillings to spend down there. At any rate the poor people have not. I think I am the only person at all of any means who lives in that neighbourhood for any distance.

Your contention is that the gas-works should be removed altogether?—No, I do not think so at all. I do not think that follows.

What do you want more than protection against the nuisance, when the Act of Parliament says that they shall not do anything which shall cause a nuisance?—I simply come here to ask the committee if they will be kind enough to consider the position in which we are placed in the East-end of London. The inhabitants there have very great confidence, I believe, in myself, and they ask me to represent that they are suffering

from a nuisance of a character which I do not think anybody sitting round this table can have any conception of. I can go and live elsewhere, if I choose, to-morrow morning, but these poor people cannot. They must live near the East and West India Docks, where they get their livelihood.

You represent that there is a nuisance, but you have taken no steps, either at law or otherwise, to put an end to this nuisance. Do you know whether or not the law is sufficient to enable you to put an end to it?—I have not gone so far as that. I have a great hatred of law, and would far sooner come here to see if I can get a remedy in a cheaper manner, by spending half an hour in this committee-room.

I see, you come here to do it cheaply?—I am quite prepared to spend my money in hospitals, and things of that kind, in the East-end of London, but I do not see why I should put my hand in my pocket to spend money in litigation.

Do you not think it would be as well to minister to the health of the people outside the hospitals as well as inside?—I have done that all my life.

Would you not effect that if you were to spend a little money, so as to put the law in force?—No; I do not see it.

Re-examined by Mr. MICHAEL: It is because this clause has not been a sufficient protection to us that I ask the committee to alter it. I do not think any one can have any conception of what we are suffering at the present time.

Mr. *Lewis Angell*, examined by Mr. MICHAEL.

I am a member of the Institution of Civil Engineers, and also engineer to the West Ham Local Board of Health. I reside in Stratford. The Bromley works of The Gaslight and Coke Company are situated in Canning Town, in the parish of West Ham. The nuisance is one of the most intolerable I have ever experienced. The West Ham Local Board have had complaints from residents a mile and a half to two miles from the works. There is a population of 100,000 people in West Ham, besides the surrounding populations of the adjoining districts. Those complaints have been received from all classes, from the highest to the lowest. We have also had memorials from the Metropolis on the other side of Bromley and Bow. We have had private letters sent to us, and also the officials of the populous district have communicated with us, in order to put the law in force. We have been complained of very seriously because we have not put the law in force, it being alleged that the board have not taken sufficiently energetic means to suppress the nuisance. We have had an influential memorial from residents in the metropolitan district, signed by the Vicar of Bow, Sir Edmund Hay Currie, and people of that class. I have traced the nuisance to the gas-works. Proceedings are pending at the present time, by the local board, against the gas company in the superior courts. The West Ham Gas-Works, also within our district, do not create any nuisance whatever. I have heard no complaint, nor have I at any time traced anything to them. I believe they are not under any obligation to reduce the quantity of sulphur to 15 or 20 grains. They use the oxide of iron process. They used lime some few years ago, and then there were occasional complaints; but since they have given up lime there have been no complaints. I have not heard any complaints that their gas is more impure than the gas supplied by The Gaslight and Coke Company. I burn the West Ham Company's gas, and have not found any bad consequence resulting either to property or health. I have not seen any evidence of the West Ham gas producing those results which are said to arise from having a larger quantity than 20 grains of sulphur. My gilt frames are the same as average gilt frames, and not in any way darker than those in other districts. There is no injury to property which I have traced to sulphur in gas. If that injury had arisen from sulphuric acid, it would hardly have occurred without my noticing it.

Cross-examined by Mr. O'HARA: I live at the Grove, Stratford, which is about a mile and a quarter, I should think, from the gas-works. I have been woke up in the early morning by the smell; it is so conspicuous and intolerable that there is no mistaking it.

Mr. O'HARA: As to these proceedings in the superior courts, do you know who advised them? How did you begin them?

Witness: In consequence of the complaints which were made. It is one of the standing discussions at our board; there is scarcely a meeting at which this matter is not mooted. Our clerk is the solicitor to the board, and he was instructed to take proceedings against the company, and the board certainly entertain the hope that those proceedings will be successful. Of course, we shall be quite satisfied if the stink is abated.

By Mr. ROUND: The company's officials have told me that they have adopted the very best practical process for purification—namely, the process prescribed by the Referees—and that they can do no more. They admit the nuisance, but they say that they can do no more than they are doing to abate it. I have been over the works repeatedly, and have been shown what they were doing, although I am not sufficiently a gas engineer to be able to form any judgment about it; but I considered they were doing all they could.

By the COMMITTEE: The West Ham parish is a very extensive one. I am living about half a mile from the West Ham works, and therefore very much nearer those works than The Gaslight and Coke Company's works. The West Ham works are in the midst of our population. There is a very great difference in the relative size of the works. The West Ham Gas-Works would perhaps be about one-fourth of the size of the Chartered Company's works. They supply a large district out by Woodford and Loughton. We suffer no inconvenience whatever from the West Ham Gas-Works.

Mr. *Richard Henn Collins*, examined by Mr. MICHAEL.

I am a barrister-at-law, and have resided at 32, Redcliffe Gardens since July, 1873. I was absent from London on circuit during the greater part of the summer of that year, and then went away for the long vacation. After my return I perceived a most offensive smell. I cannot say that I traced where it proceeded from, but I was told. I observed the smell particularly in the mornings, often about five o'clock. I have been awakened by it. I have gone from one side of the house to the other to see whether it was on both sides of the house. I found it came in through the windows on one side, and then I went to the other side of the house, and found it came in through the windows on the other side. It was about as unpleasant a smell as one can possibly imagine. In the summer of 1874 the smell was so very bad that I seriously thought of leaving my house. I frequently spoke to the builder who owns most of the houses in the place, and told him I must try to get some joint action taken by the householders in the place to indict the company, or to get the vestry to remove it, otherwise I said that I, and no doubt others, would find it necessary to give up our houses.

Cross-examined by Mr. O'HARA: I went to see Mr. M'Clymont, and told him that what we wanted was joint action, to put down this nuisance by indictment.

Mr. O'HARA: Have you ever looked into the Gas Act?

Witness: No, I cannot say that I have.

Why would they not take joint action?—I understood they were taking joint action, or that the vestry were going to take it, and I am not sure that they did not begin.

Supposing they were by indictment to put an end to this nuisance, would that satisfy you?—I would not be particular as to how it is put an end to.

You are not particular whether it is done here or in Westminster Hall?—No; on the contrary.

By the COMMITTEE: I have repeatedly tried to stir the inhabitants up, but always in the hope that some action would be taken by the landlord particularly, because he owns an immense tract of new building land all about there, and I thought he would be a very likely man to set the thing going.

The COMMITTEE: Have you any idea why he discontinued the proceedings which he began?

Witness: I should state that I am not quite clear whether the proceedings ever got so far as being actually commenced. He told me that the

gas company were themselves trying to get rid of the obligation to make this stench, and that is the last thing I heard about it.

The CHAIRMAN (addressing Mr. Michael) said: Perhaps you will be kind enough to answer this question. How would it be supposing the local authority indict for a nuisance—will their statute protect the company? Is the indictment to be tried first, and then, in the event of its succeeding, and not until then, the Referees are to alter the limit?

Mr. MICHAEL: That would not, with great deference, touch the Referees at all.

The CHAIRMAN: I want to know whether it requires it to be such a nuisance as would be proved by a successful indictment?

Mr. MICHAEL: I shall be glad to have an opportunity of putting you in possession of what course must have been in the minds of the gas company when they consented to such a clause as that—perhaps it was forced upon them—or what would be the logical sequence of such a clause. Supposing gentlemen were appointed as Referees who were all practically acquainted with the manufacture of gas, then, in other words, this clause says: You shall impose such a limit, judged of by your practical experience in gas-making, as will allow the gas company to manufacture gas without creating a nuisance. There is nothing provided that will enforce the Referees (it is a matter for their private opinion) to say, "We think you can, if you so will, reduce the quantity of sulphur to 5 grains." There is no appeal given.

The CHAIRMAN: Perhaps it is my own fault that I have not made clear what I was in doubt about. Do you consider that it is entirely in the discretion of the Referees to say what is and what is not a nuisance? For instance, suppose Mr. Collins had himself applied to the Referees, or suppose Sir Edmund Currie had gone on behalf of 50,000 people whom he spoke of, would the Referees then, do you think, have it in their discretion to say whether it amounted to such a nuisance as was contemplated by this section without further proof?

Mr. MICHAEL: The view I take of it (it matters nothing what another tribunal may say) is that it leaves this matter entirely untouched. It does not say that a nuisance shall be created, but it says that the gas shall be purified in such and such a way. The only restriction is that they shall not impose such a limit as that it cannot be done without creating a nuisance, which is another point entirely. That you may prove before a tribunal that a nuisance is created, does not at all touch the discretion of the Referees. There is no obligation on them to say, "You shall conduct it by such and such a process;" so that, although you may have one thousand injunctions, it does not touch the discretion of the Referees at all. They will say, "It is simply for you to decide which plan you will adopt."

The CHAIRMAN: I think you hardly see my point. What we want to arrive at is whether it is not possible for the Referees to be informed of these things, and as soon as possible then to alter and remedy them if they think fit. Suppose there was a successful indictment, and the Referees were aware of that, and they went to the gas company and ascertained that all due precaution had been taken, would you consider that they would be obliged to alter the limit of restriction.

Mr. MICHAEL said the indictment did not alter the state of things at all, seeing that they must have known that there was a nuisance at that time in the locality, and yet they had insisted on some kind of process which would inevitably produce a nuisance. There was no power of appeal from the Referees. Supposing there were an indictment for a nuisance; then there would be an injunction by the Court of Chancery, after indictment, to prevent the company carrying on purification by lime, because it was quite clear that the High Court of Chancery had nothing whatever to do with the defence, which merely raised the point that it was impossible to do it in any other way. All the decisions of the Courts came to one thing. It was nothing to the Court that it could not be done in any other way. In the case of injunctions with reference to the pollution of rivers by sewage and other matters, where the local authorities had said, "You cannot prevent us pouring sewage into the river, because there is no other course open to us, and, therefore, you will cause a destruction

of health to the whole of the inhabitants, by preventing us carrying out the only available plan," the Court had said, "It is nothing to us; all we can do is to restrain you from committing a nuisance." Following that out in the present case, the Court would most likely say, "Before we grant an injunction you must proceed at law, and prove that there is a nuisance." Supposing that the nuisance was proved to the satisfaction of the Court, it would be in the discretion of the Court to act in accordance with all their decisions, and to say, "You shall not use lime." But what was the result to the Referees? If the Referees were to continue the restrictions, as far as the present state of knowledge was concerned, as lime was the only mode—if the evidence was to be believed—by which the gas could be purified at all, there were no means of enforcing it on the Referees, because the nuisance had been created by the mode which had been adopted. They would say, "There is nothing in any way imposed upon us, by the Act of Parliament, to dictate to you the means to be adopted to prevent a nuisance. All we have to do is simply this. The Act says this: 'You shall not put more than 20 grains of sulphur in your gas;' but you may use whatever means you like. We believe it can be done without creating a nuisance, and there is an injunction against this mode; an indictment does not touch it at all, and we believe you can do it without creating a nuisance."

The CHAIRMAN: Do you mean by an alternative process?

Mr. MICHAEL said by any process. It was not for the Referees to dictate what the process should be. If there were anything to say that the Gas Referees were obliged to show the gas company how their restrictions could be carried out, and that only that process should be used, then there would be relief to the gas company; but now they had an arbitrary power, and it was entirely within their discretion to say what it should be. If they had ever indicated that there was another process which might be adopted instead of the lime, in order to avoid that nuisance, then the company's case would be very much weakened. But they had never indicated any other way of doing it.

The CHAIRMAN: I think, Mr. Michael, that you hardly see my difficulty. One would think the obvious way of remedying this, if there be a nuisance, is that the people so affected, as so many preliminary steps are required for the construction of this Act, should go to the Referees, and say, "We have a grievance," and that then the Referees, among whom there happens to be an experienced gas engineer——

Mr. MICHAEL: No, sir; pardon me, there is not.

The CHAIRMAN: That is another question. At any rate, they must be supposed to be competent and impartial persons. One would suppose that the next step would be that they should inquire at the gas-works whether there is a nuisance, the cause of which can be cured by an improved system; but if they find that all the precautions they can suggest are being taken, and that still the company are under the danger of a prosecution at any time, or an indictment, is it conceivable that they would act so unreasonably as to give the company no alternative?

Mr. MICHAEL: It is not only conceivable, but we shall prove to you that it is absolutely the fact. We have placed everything at the disposal of these gentlemen; we have spent thousands of pounds to carry out their suggestions. They have never said to us, "Use the A, B, C, or D process," or any process, that we have not adopted. We do not find them coming here and saying, "If you will only modify this process you will prevent a nuisance." That is exactly our position.

The CHAIRMAN: You say you do not consider the word "nuisance" in this section is a technical term. You do not mean to say such a nuisance as would have to be proved by indictment, but you consider it to be used in the ordinary and popular sense.

Mr. MICHAEL: I am quite willing to take it either way; but I believe it is the legal sense of a nuisance. I do not know whether you had in your mind the definition of a nuisance which has been held under the Public Health Act, namely, that of injurious to health.

The CHAIRMAN: Yes.

Mr. MICHAEL: I do not think it was intended to be confined to that.

The CHAIRMAN: I am thinking of a common ordinary nuisance for which you may indict at common law.

Mr. MICHAEL: There has been rather a strict definition given to "nuisance" under the Public Health Act. I think it is wider than that.

The CHAIRMAN: It would hardly apply unless there was an interpretation clause.

Mr. COURTNEY: Your situation may be analogous to that of a Board of Health who are the owners of a piece of ground between two mills; they are not allowed to turn their sewage into the stream because of injuring the stream; they are obliged to get rid of it somehow or other. But in this case you are under the orders of the Gas Referees, who, by clause 36 of your Act, are instructed to prescribe and certify the maximum amount of impurity in the gas, subject to the condition that their orders shall not require you to make a supply of gas continuously, so as to occasion a nuisance. That is a statutory restriction upon their order. Has it occurred to you that you might possibly go to the Court of Chancery and apply for an injunction to restrain them issuing a certificate which imposed upon you a duty which could not be fulfilled without creating a nuisance?

Mr. MICHAEL: It has occurred to other parties, although it has not occurred to us, because, as I venture to say, there is an entire loophole in the whole matter. It all comes to this: What is the process? Are you tied up absolutely to that process or not? It involves an entirely different matter.

Mr. COURTNEY: That will be a question of evidence.

Mr. MICHAEL: It does not say that they shall prescribe a process which absolutely and indispensably will not create a nuisance.

Mr. COURTNEY: That is quite true, so you might be under the difficulty of having to prove a negative before the Court of Chancery, supposing you went there.

Mr. MICHAEL: We should have a double onus thrown upon us of proving a positive and a negative. I think in the Tunbridge Wells case, and other analogous cases, it has been held that the Court of Chancery has nothing whatever to do with the process, and that all they have to do with is to lay down fixedly the law, "You shall not create a nuisance." It is no defence whatever to say that you do not know of any process by which this can be done without creating a nuisance.

Mr. COURTNEY: That is quite a different point. My question is whether you could not yourself institute some process to restrain the action of the Referees.

Mr. O'HARA: To relieve you from committing a nuisance.

Mr. MICHAEL: What can be the difference between our proving it to the Court of Chancery and our proving it to the committee? If this involves a hardship upon us, and involves the necessity of the same proof that we should have to give to the Court of Chancery, is it not right that we should come to you, and ask you to legislate for us, and give us that relief which you say we ought to be permitted to obtain from the Court of Chancery? It is by the action of the Legislature that the difficulty has arisen; therefore, is it not better for us to come to you and ask you so to deal with the law, with better knowledge, so as to relieve us from being between the two stones under the action of which we are being ground to powder?

Mr. O'HARA: The 30th section prescribes the duty which the Referees have to perform, coupled with certain conditions. The moment the Referees perform that duty, and forget the conditions, they are acting *ultra vires*. Let the company refuse to obey the order of the Referees when that order is *ultra vires*, and then who will enforce the penalty? That is the way to test it. In one case you propose to relieve the company from being obliged to obey; in the other case I say let the company defy those who are doing what is illegal and *ultra vires*.

Mr. MICHAEL: That is a very nice state of things. Here you are representing the Metropolitan Board of Works, who have passed a law, and they recommend the gas company to place the law at defiance. They have got a pecuniary interest, because they get the penalties of our breaking the law. They advise us to break the law in order to avail themselves of the penalties.

Mr. O'HARA: We say that the Referees act thoroughly within the law, and that there is no breach of the law, and you dare not defy them.

The CHAIRMAN: May I ask by which side the Referees will be called, because it seems to me that this Act of Parliament contemplated that the Referees might carry out its provisions according to the intention of the Act?

Mr. MICHAEL said the course which had usually been adopted was that neither side should call the gentlemen exercising such functions, but that the committee should themselves call them.

Mr. ROUND said he was instructed to appear by the Board of Trade, who had no opinion whatever upon the merits of this Bill, as to whether it was proper that the restriction which was placed last year upon the company should be repealed now or continued. All they felt was that, so long as their officers, to whom certain duties had been entrusted, exercised those duties to the best of their ability, and in the discharge of them had not laid themselves open to any imputation of *mala fides* or corruption in any way, it was a matter of indifference to them. He did not himself propose to put the Referees into the box, as he did not conceive it was at all necessary for the purpose of defending what they had done. They were simply discharging their duty, according to what seemed to them to be the mode defined by the Act of Parliament, and they had nothing whatever to do with what the results might be. Of course, if the committee thought that the Referees could give any information, they, in the exercise of their discretion, would take what steps they thought right.

The CHAIRMAN: What do you suggest is the check upon the Referees in the discharge of their duty? I suppose they would not be re-appointed next year if there were complaints made to the Board of Trade. Is that the remedy, or what is it?

Mr. ROUND said the Referees might be bound, in the exercise of their discretion, to see whether or not, in their judgment, everything had been done that could be done. It did not devolve upon them either to suggest or to dictate to the company any particular process by which the purification could be carried out. The Referees might be entitled to say, "There is not uniformity in your system; you adopt one process at one branch, and another process at another branch. We have formed the opinion that at A, where you have adoped a certain process, there have been no complaints of a nuisance; but at B, where you have adopted the same process, or have adopted a different one, there are complaints." The Referees might say there was want of uniformity.

Mr. MICHAEL: Do you say that that is the case?

Mr. ROUND: I am merely putting that as an illustration.

Mr. MICHAEL: If so, I suppose the Referees will be called to prove it.

Mr. ROUND said the Referees were no partisans in any way whatever: they were simply discharging a public duty. The Board of Trade thought it was incumbent upon them, if the conduct of the Referees was inquired into, to see that they should not be unprotected; but their view was that they had nothing to do with the question raised by the Bill or otherwise. They had appointed good men, as they thought, and until their conduct was impugned in any way, it was not proposed to call them.

The CHAIRMAN: We do not in the least impute any misconduct to them, but the phase which the case seems to take now is this: On the one hand the gas company say, "It is impossible for us to conform to your requirements without creating a nuisance," and, on the other hand, the public say, "It is impossible for us to endure this smell." The Act of Parliament says, "You are not to inflict such a limit of impurity as will create a nuisance," and what we want is to have an explanation from these public officers.

Mr. ROUND said the duty imposed upon the Referees was to reconcile two things—viz., a certain maximum amount of purity of gas coupled with no nuisance.

Mr. MICHAEL hoped that it would not be thought that he imputed any kind of misconduct on the part of the Referees, as he begged to disclaim that most entirely.

The CHAIRMAN requested the Referees to be in attendance on the following day.

Mr. ROUND said he ventured to think that the whole case should be concluded on the part of the promoters, and that then any explanation which the Referees could give should be given. If the Referees were called at that stage, it would be practically giving the company an opportunity of shaping their case so as to be a reply upon the Referees.

Mr. MICHAEL: If there is anything presented by the Referees against us, ought we not to be able to answer any allegation they may make? Is it not your wish that the committee should hear the whole case, and know the whole truth of the matter?

The CHAIRMAN said the present application was made on behalf of a company who were asking for an alteration in the Act of Parliament under which they were working. It turned out in the course of the inquiry there was a state of affairs apparently existing which had not been explained, and the committee thought that the people who could best explain it were the Referees themselves, the question being as to the exercise of their discretion as public servants. The Referees were the servants of the Board of Trade, and, therefore, they did not come as partisans for one side or the other, but only to explain their conduct. There was no imputation of *malfeasance* upon them; but there was a state of affairs which the committee did not quite understand, and which required clearing up.

THURSDAY, MAY 10.

Lord *Charles Thynne*, examined by Mr. MICHAEL.

I have resided at Redcliffe Gardens since the year 1870. When I first lived there I remarked that the neighbourhood was so singularly free from any bad smell that I determined to purchase the house. After my return from Ireland in 1873 we were very much annoyed by a most disagreeable smell, that pervaded the whole house when all the doors and windows were closed. In consequence I wrote to the Metropolitan Board of Works, and complained to them upon the subject. A rigid examination was instituted in the sewers and drains, and it was found that no bad smell arose from that source. It was subsequently traced to the works at Fulham of the late Imperial Gas Company. I inquired there as to the source of the nuisance, and I was told it was the result of a process of purifying the gas, which had been changed in 1873. Up to the present time I have found that the nuisance has been of an unfailing and unendurable character; of course, it depends upon the quarter of the wind. When the wind is in the south or south south-east, which is in the direction of the Fulham station, I suffer from it very considerably, but not when it is in other quarters.

Cross-examined by Mr. O'HARA: I made a representation to the resident engineer of the gas company a few months ago. I took no further steps beyond calling upon the Metropolitan Board, because it seemed hopeless. They told me at the gas-works that it was due to a new process of purification.

Mr. *John William Mellor*, Q.C., examined by Mr. MICHAEL.

I have resided in St. George's Square since the end of 1866, and my house has been subject to bad smells at intervals ever since. I think recently the smell is rather worse. I usually perceive it when the wind is in the east. My house is on the west side of the square, and the smell comes straight across from the gas-works. I think I can remember about half a dozen instances in which the smell has been very bad in the night. I have been awakened, I think, three times myself by the force of the smell. I generally walk from my house to Westminster in the morning. I walk along the Grosvenor Road, and as soon as I get near the gas-works the smell is perceptible every day. The very bad smell of which I complain has only been perceptible in the night on about half a dozen occasions. It produces a suffocating feeling, but I cannot say that I have been sick, although it has made some of my children feel sick. I feel it chiefly with a moist atmosphere, undoubtedly. I have been to the gas-works to make inquiries, and ever since 1866 I have received assurances from the persons to whom I complained that the works would probably before long be taken out of

London, and I, sincerely trusting that that might be the case, took no further steps until the letter was written which was read to the committee yesterday. I should like to say that the gas is manufactured in a low building, which, so far as I can see from passing, has open windows with wooden bars across. It occurs to me that the place in which these works are situated is a very bad one for the neighbourhood; and that is, I believe, the general feeling of the inhabitants of St. George's Square. Upon the night before that letter was written—it was written on the 23rd of November—I had suffered very much from this smell. There are 124 houses in St. George's Square, and I went to No. 124, the office of the trustees, to complain. As I was going there I met a friend, General Anstel, and I found he was going for the same purpose as I was. We compared notes, and I suggested that a strong remonstrance should be sent to the gas company. I saw Mr. Sclater-Booth, and afterwards we agreed to send the letter. At that time we were not aware that any Bill was about to be promoted by the gas company. I think very probably, if we had been aware of it, we should have had a meeting, and endeavoured to be represented upon the occasion, because this matter has been a serious nuisance to many of the inhabitants.

The COMMITTEE: Do you mean to say you would have supported the Bill?

Witness: That I cannot say. I am not sufficient chemist to know whether it is the fault of the gas company or not; but when the letter was written my strong impression was that it was owing to the negligent way in which the gas was purified. I am told by the gas company that I am wrong in that, but I thought it desirable the committee should know my view.

Mr. ROUND said that in conformity with the wish expressed by the committee, two of the Referees, Mr. Vernon Harcourt and Dr. Pole, were present, and were prepared to give the fullest information upon any subject on which it was desired.

The CHAIRMAN: As you were present yesterday when the idea arose of asking those gentlemen to attend, if you will be good enough to commence the examination, then we can ask them whatever we think necessary.

Mr. *Augustus George Vernon Harcourt* called.

The CHAIRMAN (to witness): I wish to say that we have not asked you to come here as a witness either in support of the Bill or against it; but we have thought that perhaps it would shorten the inquiry, and be the most convenient process, if you would throw some light upon the practical operations by which you execute your office under the clause of the Act.

Witness (in examination by Mr. ROUND): I was appointed one of the Gas Referees in 1862, in connexion with Dr. Pole and Professor Tyndall. The first step we took with regard to the carrying out of section 30 in The Gaslight and Coke Company's Act of 1876 was to put ourselves in communication with the engineers of that company. We visited the different gas-works, to observe what modes of purification were in use. With the exception of the small Silvertown works, which we had not to do with, we visited all the works shown on the map. The first notification we made as to how many grains of sulphur might be allowed, consistently with the non-creation of a nuisance, was in September, 1872. The maximum amount that we thought justifiable in prescribing was 20 grains for the suburban works of Bow and Beckton.

Mr. ROUND: How far may that be said to have been done with the assent, or, at least, without the dissent of the gas company?

Witness: We endeavoured, as far as we were able, to obtain the assent of the gas company.

May I say that you succeeded? Can you fairly say that they were parties to that maximum of 20 grains?—I do not know how far; I can say that their assent was not required, but we endeavoured to obtain it.

Was there any direct opposition on their part?—I believe it was understood that we were required to fix a maximum, and, as far as my memory

serves me, the maximum prescribed by us was considered reasonable. The following are our certificates since 1872:—

Half-yearly Periods.	Suburban Works. Grains.	Urban Works. Grains.
Winter half year, 1872–3	20	—
March to June, 1873	20	—
June to September, 1873	20	25
Winter half year, 1873–4	20	20
Summer half year, 1874	20	25
Winter half year, 1874–5	20	25
Summer half year, 1875	15	20
Winter half year, 1875–6	20	25
Summer half year, 1876	15	20
Winter half year, 1876–7	20	25

For the urban works the amount of sulphur was only recorded for 1872 and 1873; a portion of it was not fixed, but from June to September, 1873, we prescribed the actual amount for both suburban and urban works. In prescribing the various amounts of purity we thought we were acting conscientiously and in the discharge of our duty, and that we were prescribing an amount that was reasonable and practicable to obtain. During the first four years—from 1872 to 1876—complaints about the nuisance were comparatively few and unimportant; there have been more complaints within the last six or nine months than during all the preceding period since we have been Referees. Shoreditch, Pimlico, Fulham, and Bromley are the four stations from which we have complaints.

Mr. ROUND: As to each and all of them, you have been asked by the Board of Trade to inquire into and make special reports, have you not?

Witness: We have visited them all.

Mr. MICHAEL: Would you kindly answer the question?

Witness: I believe it was not for the Board of Trade that we were asked to visit them in all cases. The reason I so limited my answer was, that I believe, in the case of the Pimlico works, it was a letter which was forwarded to us addressed by the solicitor, I think, of the gas company to us. It was not the Board of Trade who set us in motion in that case.

Mr. ROUND said he would confine the matter in the first instance to the Shoreditch case, and would read a letter, dated the 18th of October, 1876. It appeared that Mr. Walker, the vestry-clerk, addressed a letter to the Secretary of the Board of Trade, to the following effect:—

I am directed by this vestry to call the attention of the Board of Trade to the fact that a great and unbearable nuisance is caused by the operations carried on at the works of The Gaslight and Coke Company in Haggerston, which, it is alleged, arises from the mode of purifying the gas from lime, rendered necessary by the Gas Referees having prescribed a standard of purity which cannot be obtained without causing the nuisance complained of. The particulars are more fully set forth in the report (copy enclosed). I am to ask whether the Board of Trade are prepared to advise that the orders of the Referees may be so relaxed as to permit the nuisance complained of being discontinued, otherwise this vestry will have no alternative but to apply to the Court of Chancery to restrain the company from pursuing its operations.

The report was as follows:—

On Monday morning, the 9th inst., information was received by the sanitary officers, that during the night of Sunday, a most offensive nuisance had been caused by the Haggerston Gas-Works, Great Cambridge Street. Complaints were made by many persons, and the whole district, including even Hackney, was greatly alarmed. The medical officer and inspector immediately visited the works, and had an interview with the engineer, who explained the cause to the medical officer, and promised that, although he was working under great difficulties, the nuisance should not, if possible, be repeated. It was not particularly discernible on the following day or night, but it recurred on Tuesday night almost, if not quite, as bad as on Sunday.

On Wednesday morning, the medical officer, after consulting the vestry-clerk, served a notice on the company to discontinue forthwith the process causing the nuisance, failing which the promptest legal steps would be taken to restrain the company from proceeding with such operations. Since that time the nuisance does not seem to have occurred with any marked intensity, although symptoms of it have appeared; but it is more than probable that, unless the operations causing it are discontinued, it will occur almost constantly, and with great intensity during the winter.

From an inspection of the premises by the medical officer and vestry-clerk, and from conversations with the engineer, the facts of the case seemed to be thus: Coal gas, as it

comes from the retort, contains a variety of impurities which have to be removed before it is delivered to the consumers; the most conspicuous and offensive of these is sulphur in some form or other, and the worst of all forms is sulphuretted hydrogen. This is a gas easily detected by its filthy odour, and in the smallest quantities by the simplest of chemist's tests. It can be entirely removed economically, and without causing any or but the slightest nuisance; and it is for these reasons entirely prohibited by Act of Parliament from London-made gas. The means by which this impurity is or ought to be removed is the filtering the gas through oxide of iron. But there are other sulphur impurities, the presence of which can only be detected by delicate and tedious chemical experiments, and these exist in gas, if the iron process of purification has been adopted, in amount varying from 30 to 40 grains of sulphur per 100 feet, which some eminent chemists declare is practically an inappreciable and harmless quantity.

The Gas Referees appointed by the Board of Trade have the power to fix the amount of impurity to be allowed, and they have, as regards sulphur, fixed it at 15 and 20 grains relatively for summer and winter in the outlying works at Beckton and Bromley, and at 20 and 25 grains relatively for summer and winter in the town works, where lime cannot be freely used. It is the removal of the excess of sulphur over 25 grains at the Haggerston works—probably from 7 to 10 grains per 100 feet—that, as we are informed, causes all the difficulty and nuisance. Sulphur in this form, according to the Gas Referees, can by no known process, practicable on a large scale, be eliminated other than by passing the gas through lime which has already been fouled by sulphuretted hydrogen. For this purpose, and in order to supply gas of required purity, the company have recently erected in Great Cambridge Street a series of extensive lime purifiers. In the course of a few days (from five to ten) the lime contained in them becomes completely saturated with sulphur in its most volatile and offensive forms. When this is the case, it becomes necessary to open the tanks to the air before workmen can enter to remove the foul lime, and the gas which is given off, when the tanks are so opened, is the nuisance so complained of, and there is no doubt that it is a most foul, offensive, and dangerous poison, which ought not to be allowed in any urban district.

The Gas Referees speak emphatically in their reports of the use of lime as causing a most intolerable nuisance, but they make in their standards an allowance of only 5 grains of sulphur per 100 feet between the works of Beckton, some miles from London, and Haggerston, St. Pancras, &c., in the very midst of the population. By the Gas Act, 1860, the companies were bound to supply gas containing not more than 20 grains of sulphur per 100 feet, but as a matter of fact the companies never did so. At any rate the Referees admit that the violations of the Act in this respect were of daily occurrence.

By The Gaslight and Coke Company's Act, 1876, under which the Haggerston works are now carried on, "the Referees shall from time to time ascertain with what degree of purity the company can reasonably be required to make and supply gas continuously without occasioning a nuisance to the neighbourhood in which the works are situate, and shall thereupon prescribe and certify the maximum of impurity to be allowed." Now, if the information which the company's engineer has given, respecting the means of purifying, and the cause of this nuisance, be correct, then it is clear that the Referees have prescribed a degree of purity which cannot be attained at town gas-works without causing a great and continuous nuisance, and in so doing have violated the very terms of the Act itself. We are informed by the engineer that the nuisance is only temporarily abated, and that in the winter approaches it will be repeated with greater intensity, so long as the lime process is continued. Whether this be a fair statement of the company's difficulties, or an exaggerated one, we cannot say. That is a matter which the company and Referees may settle. As the nuisance is such as to be intolerable, and having regard to the alleged cause of it the only means which we can suggest for its prevention are, an immediate reference to the Board of Trade, to the Gas Referees, and also to the company, setting forth the facts and complaints above given, and requiring the immediate discontinuance of the process which causes the nuisance; and, in the event of these not having the desired effect, an application should be made to the Court of Chancery, to restrain the Gas Referees from prescribing such a degree of purity as can only be attained at these works by a direct infringement of the company's Act, and to restrain the company from continuing the process. We make these suggestions not upon any legal advice but as our own responsibility in default of what appears to us the prompter and more feasible remedy.

That letter was signed Henry [illegible], Esq., Vestry-Clerk, and was sent to the Board of Trade, who addressed the following letter to the Referees dated Oct. 20.

Gentlemen.—I am instructed to transmit to you herewith a letter which has been received from the vestry of St. [illegible], complaining of a nuisance caused by the works of The Gaslight and Coke Company, at Haggerston, and to request that you will favour the Board with your observations thereon.

To that letter the following reply was sent by Mr. Vernon Harcourt, and addressed to the Board of Trade.

I beg leave to acknowledge [illegible] the attention of the Gas Referees [illegible] Board of Trade [illegible] us with copies of their letter to the Board of Trade and its enclosure [illegible] originals herewith.

On the 22nd of November, 1876, the following reply, signed by Mr. Vernon Harcourt and Dr. Pole, was sent to the Board of Trade:—

We have inquired into the cause of the gas nuisance in Haggerston, to which our attention was called by your letter of the 20th of October (R. 7506), and the letter and report enclosed therewith from the Medical Officer and Vestry-Clerk of St. Leonard Shoreditch.

We have paid two visits to the Shoreditch Gas-Works, and have witnessed there the discharging of a lime purifier, which is the operation stated in the above-mentioned report to be the cause of nuisance.

During a part of the time occupied in discharging the purifier, we made a circuit of the immediate neighbourhood of the gas-works, and observed in what positions and to what extent the smell of "foul lime" was perceptible.

We also inquired of the occupiers of houses or shops at short intervals throughout the circuit, whether they had suffered any nuisance from the neighbourhood of the gas-works; and if so, at what times.

Our own observations showed that the foul lime smell was perceptible, on the side towards which the wind was blowing, at some distance from the works, and we believe that it may be carried to a considerable distance—probably half a mile or more—before it ceases to be recognizable; at the same time, the smell was not, in our judgment, very offensive, even close to the works; and the statement in the report, that "the gas which is given off when the tanks are opened is a most foul, offensive, and dangerous poison," is not in accordance with anything that we have observed at Shoreditch or elsewhere.

The questions addressed by us to persons living in the neighbourhood of the works received, in most cases, the same answer—viz., that three weeks ago there had been bad smells from the gas-works, but not since then. One or two persons had nothing to complain of, and one or two others had noticed a smell from the gas-works more recently. One smelt it every night, whereas a purifier is only discharged every fourth or fifth day; another thought it very bad that morning, but fixed the time at which he had first observed it two hours before the purifier was opened.

It seems probable that the nuisance which occurred in the middle of last month was caused by a process of ventilating the purifiers, which was intended to diminish the risk of nuisance, and which it was reasonable to try. But, unfortunately, under the actual conditions of the experiment, this process seems to have caused far greater nuisance than that which it was designed to avert.

The manufacture of gas cannot be conducted without the production of a certain amount of unpleasant smell, of which the occupiers of houses in the immediate neighbourhood of the works are naturally inclined to complain. When any new process slightly aggravates the unpleasantness, an outcry is easily excited; and when the process is one which the company have reluctantly adopted in lieu of a less costly and troublesome, but also less efficient, process, and when the local authority, as in the present case, simply accepts and records the opinions of the company's engineer, it is inevitable that the evils of the process should be exaggerated, as they undoubtedly are in the Haggerston report.

According to the best judgment we can form, the process of purification by lime, as now conducted at the Shoreditch works, can scarcely be considered to occasion a nuisance to the neighbourhood in which the works are situate. And we think the risk of nuisance may be further reduced by additional precautions.

Examination resumed: I formed my opinion from statements made to me at an interview at our office, at which the secretary of the company and the superintendent from those works were present; and from the account they gave of the nature of the nuisance, and from the statements that the smell which they considered had been objectionable was the smell of heated naphthaline. I also arrived at the conclusion, which was formed from inquiries upon the spot, that the nuisance arose from accidental miscarriage of the process of ventilating the purifiers, which had resulted in producing the high temperature in the oxide purifier, through which the air which is passed through the lime purifier is sent. The wooden sieves, I understood, had been burnt, and, as far as I could judge, the nuisance had been occasioned by that exceptional cause.

Mr. ROUND: I think prior to that the company had asked you to come and meet them upon the spot. This is a letter by Mr. Phillips, addressed to you, dated the 11th of October, 1876:—

Dear Sir,—Our engineers are experiencing difficulty in dealing with their foul lime, and notwithstanding all the pains they take, they are threatened with legal proceedings on the ground of nuisance. In the hope of being able to obtain some amelioration of your notification, the directors are very anxious that I should see you and your colleagues.

Then there was a meeting held, and you acceded to their request and went, did you not?

Witness: We visited Haggerston, as appears from this letter.

Mr. MICHAEL: You answered that letter on Oct. 17, 1876:—

I can meet you in town on any Monday, Wednesday, or Friday, that may be convenient to you. Shall it be next Monday, at our office, at eleven o'clock? I will write to my colleagues to endeavour to make an appointment for that day. I have written to our clerk to direct him to send you the six copies of our last notification, for which Mr. Bush has asked."

Witness: It was in consequence of that letter that the interview took place, at which Mr. Phillips, Mr. Clark, and, I think, also Mr. Evans, were present, and it was from the statements made at that meeting that I first formed the opinion that the nuisance was due to the miscarriage of the ventilating process.

Mr. ROUND: You told me what your opinion was. I only wanted to show how it was that you formed this opinion. Then, on the 24th, they write you this letter, signed by Mr. Phillips:—

While we were with you yesterday, the parish authorities of Shoreditch were at our works there, and, I am told, came to the determination to apply for an injunction to restrain us from the use of lime. I do not like to appear unduly pressing, but I cannot help thinking that your decision admits of no delay. A suspension of your order would allow us to use oxide of iron for the moment, and give you time to reconsider the whole question.

On the following day you answer that letter, writing to Mr. Phillips, and say:

We will reconsider the question of the difficulty of lime purification in London as soon as possible. I believe Dr. Pole will be in London before the end of the week. I wish to see the process of purification at Shoreditch, which is the subject of complaint. Friday, the 27th, would suit me, but if Mr. Clark has to attend your board meeting, I would postpone coming till Monday, the 30th; meantime I think it likely that the remedy lies in your own hands. Both from the account of the nuisance given by Mr. Evans and Mr. Clark, and from the fact that lime purification has been carried on for between two and three years without this outcry arising, I incline to think that the aëration of the purifiers is the cause of the nuisance. If the gas is thoroughly purged from ammonia before it enters the purifiers, and if the foul lime is got quickly into barges and sent away, I believe after much watching of the process that nuisance may be avoided.

Mr. MICHAEL: You have not visited the works then; it was a visit to your office that Mr. Phillips made?

Witness: It was an appointment to meet at our office in the first place.

Mr. MICHAEL: All this took place before the visit to the works?

Mr. ROUND: It is, nevertheless, the fact that you went there and witnessed the opening of one of those purifiers?

Witness: Yes; the interview you have referred to took place prior to the letter that you read.

You went there and saw one of these purifiers emptied?—Yes.

You had better explain what was the conclusion you arrived at when you saw it opened?—It was the conclusion stated in the letter—that the nuisance was due to a temporary cause, and then at the time of our visit the nuisance was very slight, and we found by inquiries among those who lived round the works that some had observed no nuisance, and that those who had observed the nuisance referred it very constantly to the period at which this over-heating of the purifiers had taken place.

Mr. ROUND: I think that explains Shoreditch, as far as I am able to deal with it.

Mr. MICHAEL said there were two letters which he thought ought to be read, of Nov. 6 and Nov. 9.

Mr. ROUND said he would read the letter from Mr. Vernon Harcourt to Mr. Clark, dated Nov. 6:—

The Gas Referees are desirous of witnessing the operation of opening and emptying a lime purifier, as conducted at your works. The rate at which the purifiers become exhausted is probably known to you sufficiently to enable you to name one or two days between which we may choose. Friday next would be convenient to me, or the Monday following. Please address your answers to the Gas Referees at this office.

The letter of the 9th was written by Mr. Vernon Harcourt to Mr. Clark:—

I am obliged by your letters of the 7th and 8th. To-morrow (Friday) would have suited me; but I hear from Dr. Pole that he will be engaged, and I do not know whether Dr. Tyndall would be able to come, I think, therefore, it will be best to fix a day, if possible, sufficiently beforehand for us all to come. I understand that you have to

change about three purifiers a fortnight, and think, therefore, that next Thursday or Friday (16th or 17th) another may be ready to be emptied. Please let me know as soon as you can whether you will be emptying a purifier on either of those days, and I will arrange with my colleagues. We should like to be present when the lid is raised. I think the difference between the upper and the lower part of each layer of lime depends on the accumulation of moisture in the upper part. Drier lime has more affinity for carbonic acid, wetter lime for sulphuretted hydrogen. If you can easily do so, I wish you would try the experiment of placing, on the second tier of sieves from the top, lumps of quick lime (from the size of a nut to that of a tennis ball) so that the sieves may be covered to an average depth of 1½ inch. I believe this layer will be thoroughly first hydrated and then carbonated before the purifier comes out, and if so it may be possible to have every other layer at least thus charged with dry lime and inoffensive when the purifier is emptied. Of course there will be holes in a layer thus formed. But I believe holes do no harm if they occur pretty evenly over the whole surface.

Witness: The object of that experiment was not to reduce the sulphur further—that was not the letter to which mine was an answer, but I suppose that Mr. Clark represented that the lime came out in an inconveniently wet condition, and my suggestion was to sacrifice one of the purifiers to some extent, so far as its service for purifying gas was concerned, by putting upon it layers of quick lime, which would serve to dry the gas passing through it, so as to cause a less deposition of moisture in the layers above.

Mr. ROUND: In point of fact, the suggestion referred to in this letter did not apply to the particular matter now under the consideration of the committee. It was no question whether it should be 20 or 25 grains?

Witness: Not at all. I may say that I have had a great deal of correspondence at many times with the managers of these works, and I have always taken the liberty, when I have been writing, to make any suggestions which it has occurred to me might be of service to them.

Mr. MICHAEL: Did the engineer carry out your suggestion?

Witness: My recollection is that when I saw him he offered to do so, but I believe he was no longer finding the same difficulty. Some change had been made, I think, in the condensers, so that the lime no longer came out as wet as it had come out before, and, therefore, the object for which I made the suggestion no longer needed to be attained.

Mr. ROUND said he had exhausted the case of Shoreditch, and proposed to go to the Pimlico complaint, with reference to which the following letter had been addressed to the Board of Trade, dated Jan. 4, 1877:—

Among the papers which accompanied your letter to us of the 11th of December were some complaints of a nuisance proceeding from the gas-works in Lupus Street, Pimlico.

We had previously heard nothing of these complaints; but on receiving your letter we thought it our duty to visit the works in question, and make inquiries on the spot.

We called at the office of Mr. Cubitt, who had made a complaint on behalf of his lessees living in the neighbourhood of the works, and from the report of Mr. Cubitt's agent, confirmed by our own observations, as well as from the memorial which you have forwarded to us, we have no doubt that at certain times a nuisance is occasioned.

On inspecting the processes in use for removing the refuse lime, we had no difficulty in tracing the nuisance to its source.

It does not arise within the works, the manager of which appears to succeed in performing all the necessary operations about the purifiers without causing any effluvium likely to be perceptible outside. It arises during the discharge of the refuse lime into barges lying on the river quay.

The works being separated from the river by the Grosvenor Road, the company cart the lime from the purifier to the river side, where it is thrown from the carts into the barges generally lying at some depth below. This process, which is carried on in the open air, causes a great agitation of the lime, which naturally gives rise to an offensive smell.

We are somewhat surprised, considering that lime purification has been used at these works for some years, that the engineers to the company have not made arrangements for effecting the transfer of the lime from the carts to the barges in a quieter manner, and under such cover as would prevent any offensive effluvium from spreading about the neighbourhood. At the Fulham Gas-Works, which now belong to the same company, precautions of this nature are taken, and we believe with success.

We are devoting our best attention to the subject of your letter, and hope shortly to send you a more general answer.

(To witness:) In this letter you find no fault with the process as far as the purifier is concerned, but what you do find fault with is the way they deal with it afterwards, in getting it into the barges?

Witness: Yes, the nuisance being not in the purifying process, but in

removing the lime from the purifying-box, and discharging it from carts into barges, lying at the river quay. It was unprotected as it fell from the carts into the barges, and on windy days it would be blown about and carried for a distance. I think the arrangements in use at the Fulham works might with advantage have been adopted.

I see you speak approvingly of arrangements at Fulham, and suggest that if they were carried out at Pimlico, the cause of nuisance would not exist?—I do not mention that as my own knowledge, but it has been mentioned by a witness, that the lime is now thrown through a shoot into the barge, which, I think, is a very ingenious and excellent method.

Mr. ROUND: Bromley comes next. On the 11th of January last you wrote to Mr. Phillips the following letter:—

Having received from your superintendent at Bromley station a notice that he would open a lime purifier yesterday, we attended and witnessed the operation.

We found that the refuse lime was emptied by manual labour into open trucks, which were drawn away and discharged upon the waste land. In this process much agitation and exposure of the lime to the air were caused, and much dust was made; the consequence being, naturally, the production of an offensive smell, which, no doubt, would be carried away by the wind.

No precaution of any kind was taken to prevent this result, except by sprinkling a little coal or ash-dust on the surface of the lime in the purifier, which did no good, as the lime was immediately stirred up again by the shovels of the men.

The deposited lime was, we found, covered over with earth; and we do not think any nuisance arises therefrom.

The works are situated in a very open neighbourhood; the West Ham district, from which the complaints come, being two miles away.

If it is found that this situation of the works does not relieve you from the necessity of using such precautions as are adopted at other works in more crowded neighbourhoods, no doubt your directors will see the advisability of taking such precautions.

I rather gather from that, that the cause of the nuisance was similar to what it had been at Pimlico—viz., getting the lime away. You say in this letter, "We found that the refuse lime was emptied by manual labour into open trucks." That was very much what you found before, I think?

Witness: No, it was not quite the same. In the case of the Pimlico works, the purifiers are under cover, and very well sheltered from the wind, so that the lime does not get blown about when it comes out in a dusty state during the operation of emptying the purifiers. At Bromley the purifiers are not so protected, and when lime is dusty, no doubt it is blown out, and may be carried to a very considerable distance.

Can you offer any good reason why they should not be covered in both cases? Do you think it is right that they should be covered?—I think the principal reason is the expense. It is an additional expense to erect sheds over the purifiers. I know of no other reason.

At all events, you think it is desirable that it should be done?—That, I believe, would be one mode of diminishing the risk of nuisance.

Mr. ROUND: That brings me to Fulham. Two days afterwards, you wrote a letter dated the 18th of January, to Messrs. Leigh and Pemberton, the solicitors for the Chelsea Vestry:

We have given careful consideration to the statement in reference to the nuisance occasioned to the parish of Chelsea by The Gaslight and Coke Company's works at Fulham, which accompanied your letter to us of Nov. 11, 1876.

We have also paid several visits to the works in question, and have watched the process of discharging the lime purifiers and conveying away refuse lime. The arrangements in use for the last-named operation, by which the refuse lime is kept constantly under cover from the time when it is lifted out of the purifier till the lading of the barge in which it is removed has been completed, seem to be good, and to be carefully carried out. We believe that no nuisance is caused during this operation.

The process used for emptying the purifying-box has recently been improved by the introduction of a plan which Mr. Evans, formerly the engineer, and now a director of the gas company, states that he employed successfully before the discovery of the use of oxide of iron as a purifying agent to prevent nuisance from arising from the refuse lime. Before the lid of the purifier is raised, air is drawn downwards through the vessel, and thence expelled through a large brick trough filled with oxide of iron. By this means both the foul gas which filled the purifier is rendered innocuous before it is allowed to escape, and also the sulphuretted hydrogen, which the lime gives out, especially when in a moist condition, on its first exposure to the air, is arrested.

Our observations, however, at Fulham and at other works, lead us to believe that the principal source of the nuisance which is liable to arise from purification by lime is not a gaseous effluvium, but the refuse lime itself, which exists, when in a dry condition, as

an exceedingly fine dust. Where, as at Fulham, the purifiers are not enclosed, but stand in the open air, and their contents are exposed to the wind while being trodden upon by the workmen and shovelled into bags, this dust rises and is carried away so abundantly that the clothes of a person standing at some distance to leeward are thickly powdered by it, and acquire a more persistent smell than would be caused by exposure to gaseous effluvium.

It is to this dust, carried as it easily may be to distances of a mile or more from the works, that the nuisance complained of in Chelsea is probably due.

The remedy seems obvious—namely, either to enclose the purifiers so as to shelter them altogether from the wind, or to lay the dust by watering each layer of lime sufficiently to damp it through before it is stirred by the workmen.

This latter process, as being immediately applicable, we have recommended to the superintendent of the works, advising also that he should employ the down draught of air suggested by Mr. Evans, not only previous to the raising of the lid, but also throughout the operation of emptying the purifier. We have also recommended that the labour of emptying should, as far as possible, be so systematized that the workmen should deal successively with different sections of each layer, keeping covered over the remaining sections. This plan has the further advantage of concentrating the down draught of air upon that area on which the lime is being disturbed.

Our recommendations have been adopted by the company, and the mode of working just described has been in use for the last two or three weeks. During this time we have thrice visited the works, and we believe that if this mode of working is carefully adhered to no further nuisance will be occasioned.

It must, however, be borne in mind that purification by lime is not the only operation in the manufacture of gas which gives rise to unpleasant smells. On the occasion of our last visit to the works, on the 10th inst., the superintendent stated that some complaints had been made to him recently; but he also mentioned that he had recently emptied a large scrubber—a vessel through which the gas passes before it enters the purifiers, and charged with coke—which had become clogged with the tar and other impurities removed from the crude gas.

We would say, in conclusion, that although it is undoubtedly easier to conduct the less complete purification of gas by means of oxide of iron without occasioning nuisance, than so to conduct the more complete purification by means of lime, we believe the latter to be practicable if proper arrangements are made, and sufficient vigilance is exercised.

It is not our province, neither are we in a position to give to the company such engineering or chemical advice as they need to discharge properly their responsibility in this matter; but we can see far enough into the question to make us believe what the Vestry of Chelsea express as their hope that "some method might be found of obviating the nuisance without sacrificing the purity in the gas."

It appears your attention was drawn to certain cases, and you suggested a remedy. The company adopted that remedy, and since then you have thrice visited the works, and believe that if that mode of working is carefully adhered to, no further nuisance will be occasioned. Has there been brought under your notice any instance of complaint, upon the ground of nuisance, since that date at those works?

Witness: I have not heard anything about it since. I might say that on these occasions I spent several hours in the works, and walked round and round, and stayed for a long time to leeward of the purifiers that were being emptied, so as to form the best observations I could of the amount of effluvium escaping from the lime, and, on those occasions, I have satisfied myself that when those precautions were being taken, even in the immediate neighbourhood of the purifiers, there was nothing offensive.

The COMMITTEE: Seeing the evidence we have had to-day from Lord Charles Thynne, of his having experienced a nuisance up to the present time very badly, your explanation would be that they have discontinued the precaution?

Witness: Or that the nuisance was due to some cause other than lime purification. I am strongly of opinion that gas-works are bad neighbours apart from lime purification.

Mr. ROUND said he had exhausted the matter as far as he thought necessary with regard to those particular cases. With regard to the general question, he would begin with a letter dated the 11th of December, which the Board of Trade addressed to the Referees, and which was as follows:—

With reference to the enclosed correspondence which has been transmitted to this department by The Gaslight and Coke Company, I am directed by the Board of Trade to make the following observations:—

There appears to be no doubt, from the information contained in this correspondence, that a nuisance is created by the present system of the purification of gas by means of lime.

It is also clear, from the terms of The Gaslight and Coke Company's Act, 1876, that

the amount of freedom from sulphur impurity which the Gas Referees are to prescribe is made subject to the condition that a nuisance is not created thereby. The only question, therefore, appears to the Board of Trade to be whether the company can restrict this impurity to the amount required by the Referees, without creating a nuisance.

I am directed to request that the Referees will state whether, in their opinion, the maximum amount, as at present fixed, of sulphur impurity with which gas supplied by the company shall be allowed to be charged can be maintained without creating a nuisance.

If, in their opinion, such a maximum cannot be so maintained, I am to suggest, for the consideration of the Referees, whether the maximum should not be increased.

The correspondence being in original, I am to request that you will be good enough to return it to the secretary to the company when you have done with it.

I am also to request that you will furnish the Board of Trade with a reply to this letter at your earliest possible convenience.

That was an important letter, because the Board of Trade had thrown it upon the Referees to report to them whether the company could restrict its impurity to the amount required without creating a nuisance.

Mr. MICHAEL: Now we have come to the general question, would you have any objection, in order to shorten the matter, to go back to the letter of the 11th of November, 1876, written by Mr. Phillips to Mr. Vernon Harcourt?

Mr. ROUND said he had not read the letter, because there was a request at the end to treat it as a private communication; but the witness stating he had no objection to its being made public, it was read, and was as follows:—

I trust you will pardon my troubling you unofficially on the subject of the lime purification, your determination as to which is the subject of much anxiety to the directors. I am privately informed that the Shoreditch and the Fulham parish authorities are resolved to indict us if the annoyance to which they were recently subjected, and which our engineers say they cannot prevent is repeated. The directors feel that they would place themselves in the wrong were they to disregard your instructions, but they are seriously contemplating an application to Parliament for a Bill of Indemnity against the consequences, and I yesterday received instructions to prepare a notice for such a Bill. I earnestly trust that between this and next Friday you and your colleagues may have seen your way to a definite answer to my application for a 40-grain maximum, and that it may be such as to relieve us from all the great trouble and cost of another parliamentary fight. Do me the favour to consider this a private communication.

(To witness:) You did answer that letter, I think? Do you recollect telling them that you could not accede to this application for a 40-grain maximum?

Mr. MICHAEL: I do not think Mr. Vernon Harcourt did that. He sent a letter on the 11th of November, signed by himself and Dr. Pole, which seems to be the answer.

Witness: I do not remember whether I sent any other.

Mr. ROUND: We will take it as a fact that you received that application from the company.

Witness: I should think I sent Mr. Phillips an answer.

Mr. ROUND: Here is your answer, apparently written on the same day. This is the letter written by you to Mr. Phillips:—

As a strong opinion has been expressed to us by yourself and Mr. Evans that the sense of the public is changed with regard to the sulphur impurity in the London gas, and that they no longer care to have the maximum kept low, we think it right to send, for your and Mr. Evans's consideration, a copy of a memorial dated the 4th of November, which has been presented by the Corporation of London to the Board of Trade, and forwarded by the Board of Trade to us.

Mr. MICHAEL: Those letters crossed—that is not the answer. You did write on the same day, but your absolute answer was written from Oxford on the 13th; and signed by Dr. Pole and yourself?

Witness: Probably.

Mr. ROUND said the memorial mentioned was sent to the Referees by the Corporation of London, expressing great anxiety that they should adhere to what they had already prescribed; but he did not know that it was necessary for him to read it. It was a fact that pressure was put upon the Referees.

The CHAIRMAN: Read that part which gives the grounds of objection, whatever they may be.

Mr. ROUND said the memorial was signed by the town-clerk, and was as follows:—

The Gas and Water Committee of the Corporation of London have received a notification from the Gas Referees as to the amount of sulphur impurity, other than sulphuretted hydrogen, to be allowed in 100 cubic feet of gas, and raising the maximum from 15 and 20 grains for the winter half year 1876-7. The 43rd section of The Gaslight and Coke Company's Act, 1876, provides "that if on any day the gas supplied by the company is of less purity than it ought to be under the Act, the average of all the testings under the Act on the preceding and on the following day shall be deemed to represent the purity on that day," and the committee therefore think that, considering the results of the testings during the last year, and the taking of the average for testing upon three days, in case of excess of sulphur, instead of the testing of one day, it is very undesirable and unnecessary that the maximum for sulphur should have been increased even during the winter months. I have therefore, been directed to request you to bring this matter under the notice of the Board of Trade, in order that the attention of the Gas Referees may be called thereto.

It appeared that the Referees had increased the maximum of sulphur, and had allowed 25 grains in the winter, and the corporation said they thought it very undesirable and unnecessary that the maximum for sulphur should have been increased during the winter months; therefore, it was putting pressure upon the Referees to say: "Do not by any means accede to the application made by the company."

Mr. MICHAEL: I now want the letter dated Nov. 13, and sent from Oxford.

Mr. ROUND: This is it:—

I have been once to the Shoreditch works since I saw you, and am going again next Thursday. I hope then that my colleagues and I will be able to witness the operation of the opening of a purifier from the beginning, and to judge, to the best of my ability, whether it is productive of nuisance, and whether it is managed as well as possible. I am sorry to hear that at Fulham, also, you have been threatened with an indictment for nuisance. I have often visited those works, and have thought that, though purification was carried on under great difficulties, owing to the very small size of the purifiers, the management of the refuse material was satisfactory.

Mr. H. Clark spoke to me of his desire to adopt a process of Hills, which is in use at the South Metropolitan works, by which gas is purified from carbonic acid, and sulphuretted hydrogen by washing with ammonia obtained from gas liquor. The process is excellent in principle, and I hear that it answers well. Either this process, or that which Mr. Patterson claims, of using a distinct set of lime purifiers to stop carbonic acid, would effect the important object of reducing the quantity of foul lime necessary to keep down the sulphur in gas to small proportions. I believe the quantity of lime which is produced on the system Mr. Clark now follows is eight or ten times as great as is required for reducing the sulphur. If the heating process which was the subject of my experiment at Horseferry Road were carried out, the production of foul lime would be dispensed with altogether.

Personally I look upon the process of lime purification as commonly conducted as very unsatisfactory. It is difficult to conduct it without causing nuisance. The refuse material seems of little or no value, and it must become continually harder to get rid of it. Better processes have been suggested, and I think that gas engineers ought to be able to bring some better process into use. Certainly the conclusion which you urge, that the attempt to keep the sulphur down to a low point should be given up altogether, is one which those who have taken the question up on the part of the consumers are not likely to acquiesce in.

Mr. MICHAEL: Now we come to the letter of the 5th of March, 1877.

Mr. ROUND read the letter, as follows:—

On the 11th of December last, Mr. Calcraft sent us, in a letter marked R. 8720, some correspondence transmitted to the Board of Trade by The Gaslight and Coke Company respecting certain nuisances stated to be caused by the system of lime purification.

Mr. Calcraft remarked that there could be no doubt that a nuisance was created, and, after referring to the Act of Parliament, requested us to state whether, in our opinion, "The maximum amount, as at present fixed, of sulphur impurity with which the gas supplied by this company shall be allowed to be charged, can be maintained without creating a nuisance?"

In answering this question, we wish first to call the attention of the Board of Trade to some facts in the history of the purification of gas from sulphur.

For nearly 30 years after gas was first used for illumination, the process universally and exclusively adopted to purify the gas from sulphur in all its forms consisted in bringing it into contact with lime, which was sometimes suspended in water, and sometimes in a solid state. The lime so used became fouled, and was liable, if exposed freely to the atmosphere, to give off offensive effluvia; but during this period, by the careful management of gas engineers, the manufacture appears to have gone on generally without impediment.

About 28 years ago another purifying agent was discovered—namely, oxide of iron. This had the advantage over lime, that it was cheaper (as it could, after being fouled, be revivified and used again), and that the effluvium when it was exposed to the air

was less offensive than that from refuse lime. For this reason oxide of iron gradually came to be substituted for lime in many gas-works, particularly in those of large size.

In process of time, however, as methods of testing gas improved, it was found that although oxide of iron completely removed from gas the most important sulphur impurity—namely, sulphuretted hydrogen, it still left an amount of sulphur in other forms, varying from 25 to 40 grains per 100 cubic feet of gas.

It will be recollected that the presence in gas of this amount of sulphur attracted considerable attention about the time that the Board of Gas Referees was first established, and formed the subject of several reports made by the Referees to the Board of Trade.

The present Referees were appointed in 1872. Our first step in the matter was to hold a meeting with the engineers of the Chartered Company, and discuss the subject fully with them, after which, with their assent, we fixed, in our notification for September, 1872, a maximum for the works at Bow and Beckton, "where lime could be freely used," of 20 grains, leaving the amount for other works still undetermined.

We carefully considered the question of possible nuisance from the use of lime in urban stations; we made ourselves acquainted with what was done elsewhere, and we found that the use of oxide was by no means common in the gas-works throughout the country. We were informed that in many large towns lime was still used; and in some which we visited we found that no nuisance was thereby caused.

We had, at the same time, abundant evidence that the public anxiety for a more complete removal of sulphur, which had found expression in the Acts under which we were appointed, had not abated. Accordingly, on March 31, 1873, we gave notice to the companies that on the 30th of June we should require gas from all works to conform to the standard of a maximum of 20 grains.

As the time approached, the companies represented to us that their arrangements for the use of lime were not perfected, and on the 30th of June we had an interview with Mr. Chubb, the Secretary of the Imperial Gas Company, and we copy from our minute-book a statement formally made to us by him:—

"Mr. Chubb stated that the Imperial Gas Company had now become convinced (and they fully admitted the fact) that by means of lime purification the sulphur could be kept down, and that by clearing the gas of ammonia the nuisance could be prevented, so as to render the lime process practicable at any of their works. But they had difficulties from the limited extent and defective arrangements of their purifiers, and they asked an extension of time to enable them to make the necessary additions."

Mr. Chubb convinced us of the reasonableness of his appeal, and on the same day we issued the following notification, raising the maximum at urban works to 25 grains:—

"17, *Buckingham Street, Adelphi, W.C., June* 30, 1873.

"The Gas Referees have to make the following announcement as to the 'sulphur maximum.' For gas made at Beckton and Bow the maximum shall remain fixed at 20 grains. But the Referees have determined, in consideration of various difficulties which the gas companies have encountered in attempting to reduce the amount of sulphur below 20 grains at works less favourably situated, to allow at these works, from this date until the 30th of September, a maximum of 25 grains. During the winter half year it is the intention of the Referees, in further consideration of the increased quantity of gas which the companies have to make, to raise the maximum to 30 grains. But the Referees wish it to be understood that they sanction these maxima for the periods named only because it appears that at several gas-works the purifying apparatus is on an insufficient scale, and in the hope that the time thus granted will be used by the companies in making such additions and improvements as will secure to the public a higher standard of purity for the future."

The board will recollect, as an evidence of the public feeling on the subject, that this concession was complained of by the authorities of the City in strong terms.

After carefully watching the operation of the system of purification by lime, we were so satisfied with the results obtained that in the summer of 1875 we made a further reduction of the maximum. The companies made no earnest objection to this, but expressed an anxiety lest we should press them further, which we assured them, in the present state of knowledge and practice on the subject, it was not our intention to do.

The following table will show the maximum amounts fixed by us for all the works under our control during each half-yearly period since September, 1872. The increase for the winter months is on account of the larger make of gas, and the consequently greater difficulty of effecting the purification. [The table referred to was given in the early portion of the witness's evidence.]

During the first four years the complaints of nuisance were comparatively few and unimportant; but within the last half year they have become more serious and general.

The papers you have sent us contain four sets of complaints in regard to the works at Shoreditch, Pimlico, Bromley, and Fulham, respectively. We knew nothing of the Pimlico and Bromley complaints till we received your letter; but we have now inquired into all, and have reported to you on each separately.

The Shoreditch complaint you will find reported on in our letter to you of the 22nd of November, 1876. The principal complaint had arisen from an accidental temporary cause, which had ceased; the inhabitants of the neighbourhood had no longer any grievance to urge, and although there was some bad smell given off, this was caused by the neglect of proper precautions.

In the Pimlico case our report to you of the 4th of January last shows that there

was reasonable ground of complaint, but that in this instance also the nuisance was clearly due to the company's imperfect arrangements for the removal of the foul lime.

A copy of our report on the Bromley case was sent to you of the 22nd of January. The works are in a very open neighbourhood, but we found that no precautions were taken in emptying the purifiers, and thus the smell was probably carried to some distance.

On the Fulham case we reported to you on the 22nd of January. At this station various well-considered precautions were taken in the removal of the lime, and, no doubt, with good effect. But the actual process of emptying the purifiers we found less satisfactory; we suggested some improvements, and we saw no reason to doubt the possibility of avoiding nuisance if proper care were used throughout.

At each of these stations, except Pimlico, the purifiers stand in the open air, a position which must lead to the spreading, by the wind, of the dust and vapours evolved during the emptying of the purifiers. In works where the purifiers are enclosed in a covered building, or shed, this effect is almost entirely prevented.

We have reason to believe that in some instances the nuisance has been due to causes independent of the lime purification; and we need hardly point out how very easily, by relaxing the necessary care in any department of the manufacture, nuisance may arise.

We believe, moreover, that much more lime is used than is requisite for the purpose of removing sulphur. At least nine-tenths of the lime employed serves another useful, but quite distinct purpose—that of removing carbonic acid, and thus improving the illuminating power of the gas. If other means (such, for example, as are now in use at the South Metropolitan Gas-Works), should be found available for the removal of carbonic acid, the discharging of a lime purifier would be a much less frequent event, and might be conducted in a more leisurely and careful manner.

It is not denied, however, that the refuse lime is offensive, and that if care be not taken the offensive smell may be carried to some distance. But it is surely nothing new to have to deal with offensive materials in large gas-works. If great care were not used with regard to their products and other processes of gas manufacture, intolerable nuisances would be occurring continually. But it is part of the duty of intelligent engineers and managers to prevent these nuisances; as a rule, they succeed in doing so, and the removal of refuse lime need form no exception if proper skill and consideration were brought to bear.

But we ourselves look on the use of lime for the reduction of the sulphur compounds as only a temporary expedient. Other less objectionable processes have been proposed which give great promise, and which probably only require energetic and skilful trial to come into successful use. And no doubt others may be discovered if the attention of gas chemists and engineers is earnestly directed to the subject.

We believe The Gaslight and Coke Company are at a considerable disadvantage in regard to their engineering. It might naturally be expected that a gas company supplying more than half of London, and having about £7,000,000 of capital, would have some eminent responsible and active head engineer to direct and control their scientific and manufacturing arrangements. But there is no such officer. Mr. Evans (whose great knowledge, ability, and experience are known to the Board of Trade as well as to ourselves) no longer occupies this position; and the management is in each case left to a local superintendent of the special place of manufacture.

We have no reason to doubt the competency of these gentlemen for the positions they hold; indeed, we know some of them to be men of ability. But we notice among them a singular diversity of opinion and practice, and some disinclination, perhaps natural, to cope with a problem new to their experience.

They have expressed their readiness to try any suggestions made by us; and we have pointed out some of the more obvious defects in the processes we have seen; but it is not our province to act as the company's engineers or chemical advisers. The absence of any well-qualified technical head with whom we could communicate on the general problem has been a source of continual inconvenience, and we are convinced that if the subject were earnestly taken in hand by a person so qualified, all the difficulties attending it would soon disappear.

It is clearly the intention of the Acts now in force that the gas companies shall be required to reduce the amount of sulphur in all forms, as well as wholly to remove sulphuretted hydrogen. The question we have had to decide is, how far this amount can be reduced, considering what is reasonable, and especially the neccessity of avoiding nuisance.

It will be seen from the preceding statement that, until the sudden outbreak of complaints of nuisance during the past half year, we had no reason to doubt the possibility of maintaining the standard of purity which we have prescribed, and now that we have inquired into the mode of working, wherever complaints of nuisance have arisen, we are still of opinion that this standard may be maintained without injury to the neighbourhood of the works, if a reasonable amount of skill and care is employed.

By the Bill which The Gaslight and Coke Company have brought before Parliament, in order to free themselves from the obligation to remove sulphur compounds other than sulphuretted hydrogen, the question is raised whether the purification of gas to the extent now practised is worth the trouble it entails. It is a question of the balance of advantages between a more complete purification, attended by a greater risk of local nuisance and a somewhat greater cost, and, on the other hand, a less complete purification at less cost, and with less risk of nuisance.

While admitting that there is much to be said in favour of the view that the presence in gas of the small amount of sulphur which lime purification removes is of no great consequence to the consumer, we are still of opinion that it would be a measure of questionable expediency to relieve the companies altogether from the obligation to make and supply gas as pure as can reasonably be required, because the main inducement to invention and effort in this direction would thus be removed.

Mr. ROUND (to witness): I see that you attach considerable importance to the fact that at each of the works you have to deal with a different engineer, and you suggest that if there was one chief engineer who would prescribe what was to be done at all the different works, the business would be much facilitated in this matter?

Witness: We found that the same problem, which is the removal of this foul lime without the creation of a nuisance, was treated differently at different works; and we thought that at some works one part of the process was well managed, and at other works another part, and in some cases scarcely any precautions we considered were taken; and we thought that if the precautions which were used for the different parts of the operation at the different works were combined and generally applied, the nuisance would be avoided.

FRIDAY, MAY 11.

Mr. *Harcourt* recalled.

Mr. POPE said his learned friend had asked him, though he was on the other side, to read some letters which it was desirable should be before the committee. The first was dated Jan. 16, 1877, and was from Mr. Phillips to the Gas Referees:—

The observations on the statement of the vestry of the parish of Chelsea, with reference to the alleged nuisance arising from the company's station at Fulham, which, in obedience to the request contained in your letter of the 18th of November last, I have to make, and with which I may couple those in connexion with other stations of the company which have been the subject of public complaint, are very few.

Prior to the year 1860 gas companies were in the habit of purifying their gas from sulphur compounds by means of lime, which is, no doubt, the most effective agent for the purpose; but the annoyance to the public caused by its removal induced this and other companies to abandon it, and to adopt the somewhat less efficient, but also decidedly less offensive, process of purification by oxide of iron.

Subsequently to 1868 the higher standard of purity required by the Gas Referees, appointed under the general Act passed in that year, necessitated a return to the employment of lime, for the use of which this company has expended, and is now expending, very large sums of capital on the additional plant required; and wherever the purifiers have been adapted to the views of the Gas Referees and brought into action there, as the evidence of the City Gas Examiner shows, the company has successfully and uniformly maintained the high degree of purity which the Gas Referees have enjoined.

I venture, however, to submit that section 36 of the City of London Gas Act, 1868, which is re-enacted by section 30 of The Gaslight and Coke Company Act, 1876, has been insufficiently regarded by the Gas Referees, because, although no question exists as to the ability of the company to obey the notification of the Referees, either theoretically or practically, it is manifest from the complaints in the neighbourhood of those of the company's stations which are nearest to densely populated districts, or to houses of a superior class, that the process necessitated by the present prescribed standard of purity is not without annoyance to the inhabitants; and of this fact, notwithstanding that it is disputed by the Gas Referees, the officers and servants of the company, as well as the public, have the evidence of their own senses.

These complaints, as they have arisen, have been reported to the Gas Referees, who have made many suggestions which have been immediately acted upon by the company's engineers, with a view to check the exhalations which arose from foul lime in the course of removal from the purifiers, but they have in no instance tended either to remove or even modify the evil; and it is now abundantly clear, first, that the standard of purity required by the Gas Referees is practically unattainable except by the employment of lime as a purifying agent; and, secondly, that nuisance to the neighbourhood in which the works are situated is inseparable from its use.

The directors, therefore, renew their application to the Gas Referees to exercise the powers vested in them by clause 31 of The Gaslight and Coke Company Act, 1876, and to fix such a maximum (say, 40 grains) for sulphur as is compatible with the use of an inoffensive purifying agent. In the event of their declining to adopt this suggestion, the directors appeal to the Gas Referees to apply to this company the regulation now imposed upon the Commercial Company—viz., that the amount of sulphur impurity to be found in the company's gas be simply recorded, pending the result of an application to Parliament on the subject in the ensuing session.

The reply to that was on the 23rd of January:—

We have to acknowledge the receipt of your letter of the 16th of January. We regret that we cannot concur in the opinion you express—that nuisance to the neighbourhood in which the works are situate is inseparable from the use of lime. The reason why no maximum for sulphur has been imposed hitherto on the Commercial Gas Company is simply that their preparations for lime purification are not yet completed.

That letter was signed by the Gas Referees. The next was dated March 28, 1877, and was from Mr. Phillips to the Referees:—

The directors of this company met specially to-day to receive from the deputation of their number who waited upon you on Monday last, the 19th inst., a report of their proceedings, and they hoped also to be favoured with your reply to the proposition then submitted, for such an exercise of your statutory powers as could admit of the avoidance of a most costly parliamentary inquiry. They are disappointed at having as yet received no answer from you, and I am instructed to request that any communication you may be pleased now to make to them on the subject may be in my hands prior to Thursday next, the 29th inst., on which day they will hold another special meeting to determine the course of action which they will adopt on the re-assembling of Parliament after the Easter recess.

To that the Referees replied on March 26, 1877:—

Dear Sir,—We are surprised to learn from your letter of the 23rd inst. that your directors expected from us a letter in reply to the conversation which passed when your chairman, deputy-chairman, Mr. Evans, and yourself, were good enough to come here last Monday. We are unable to send a reply, for the reason that no definite proposal was laid before us. Mr. Richards spoke of a desire to bring about some compromise, and Mr. Evans named 30 and 35 grains of sulphur per 100 cubic feet of gas as maxima with which the company might be content. Mr. Browne was of opinion that no maximum lower than 40 grains would effect what he desired, and you referred to a former request for that maximum, and appeared to share Mr. Browne's opinion.

Our letter to the Board of Trade in reply to the question, "Whether, in our opinion, the maximum amount as at present fixed of sulphur impurity with which gas supplied by the company shall be allowed to be charged, can be maintained without causing a nuisance," was read, not having been seen before by your directors, and you stated more than once that what you thought best was that your deputation should retire and consider that letter. The letter does, in effect, contain our answer; but if you have any further proposal to make to us, and will place it before us in a definite form, we will consider it at once and send you a definite reply.

We desire to add that we sincerely regret the expense to which your company may be put in endeavouring to free itself from the existing regulations respecting the purification of gas from sulphur. But we must remark, first, that we have not altered the standard prescribed by us since March, 1875, or that we are not responsible for the need of amending your Act of 1876; and, secondly, that we should be altogether exceeding our proper executive functions if we were in effect to annul these sections of your Act which you have now proposed to Parliament to cancel by fixing a maximum of sulphur impurity so high as to be inoperative.

That was signed by Mr. Vernon Harcourt and Professor Tyndall. The reply was dated the 26th of March, and was from the secretary of the company to the Gas Referees:—

I am instructed by the directors to acknowledge the receipt of your letter of the 26th inst. They regret that the proposition submitted to you at their interview was not made so clear to you as they thought it had been. The proposal made, and to which they looked forward for an answer, was that you should exercise the power vested in you, and extend the maximum of sulphur to 40 grains. Mr. Evans, it is true, did mention that he, in his experience, thought that possibly we might be safe from penalties with a 35-grain maximum, and that even at 30 grains it would be worth while to make the experiment. But the proposal to which the directors hoped to have an answer was, that you should extend the limit to 40 grains, and the result of the interview was that they anticipated that you would either accede to that maximum, or propose to extend the limit to 35 grains positively, or that you would suggest a temporary maximum of 30 grains by way of experiment.

Then on the 4th of April came a letter signed by Mr. Vernon Harcourt and Professor Tyndall:—

In reply to your letter of the 29th ult. we regret to have to state that we do not think ourselves justified in prescribing for the summer half year, upon which we have just entered, a higher maximum of sulphur, with which gas supplied by the company shall be allowed to be charged, than has been in force during the corresponding period of the two previous years.

That obviously closed that part of the correspondence, and then came the letter of the 7th of April from Mr. Phillips to the Secretary of the Board of Trade:—

I am instructed to acknowledge the receipt of your letter of the 19th ult., transmitting for the information of the Court of Directors of this company a printed copy of correspondence between the Board of Trade and the Gas Referees, relative to the removal of sulphur impurity from gas, in which correspondence is found your letter of the 11th of December, 1876, stating that "there appearing to be no doubt that a nuisance is created by the present system of the purification of gas by means of lime," and as "it is also clear from the terms of The Gaslight and Coke Company's Act, 1876, that the amount of freedom from sulphur impurity, which the Gas Referees are to prescribe, is made subject to the condition that a nuisance is *not* created thereby, the only question, therefore, appears to the Board of Trade to be, whether The Gaslight and Coke Company can restrict this impurity to the amount required by the Referees without creating a nuisance;" inquiring also, whether the maximum amount as at present fixed, of sulphur impurity with which gas supplied by the company shall be allowed to be charged, can be maintained without creating a nuisance;" and suggesting, for the consideration of the Referees, "if, in their opinion, such a maximum cannot be so maintained, whether the maximum should not be increased." The correspondence also includes the letter of the Gas Referees, dated the 5th ult., which is their reply to your letter.

It is desirable that I should state that on the 16th ult. the directors, unacquainted with the correspondence above alluded to, deputed three of their number, viz.:—the Honourable Richard Howe Browne, Governor, Mr. E. V. Richards, Q.C., Deputy-Governor, and Mr. Evans, late Gas Referee, and till recently the company's engineer-in-chief, to wait upon the Gas Referees, and discuss with them the sulphur question taken in connexion with the 30th section of the company's Act of 1876, quoted by you, with a view to ascertain whether, by inducing the Referees to concede an increased maximum, it were possible to obviate the necessity for the very costly inquiry which must be entailed by the prosecution of the company's Bill now before Parliament bearing upon that subject.

The deputation, still ignorant of the communications above mentioned, by appointment attended the Gas Referees on Monday, the 19th ult., and propounded the views of the court, that the existing sulphur maximum should be extended. The Gas Referees met the proposition made to them by a reference to their letter of the 5th ult. to the Board of Trade, which was then read for the first time to the deputation.

The directors thereupon restated the object of their application, to which the Gas Referees have since expressed their indisposition to accede.

It is therefore, in the opinion of the court, desirable to examine some of the allegations contained in the Gas Referees letter, and to communicate to the Board of Trade the court's views on them; but, inasmuch as the directors and their officers will shortly most probably find themselves face to face with the Gas Referees before either a Parliamentary Committee or a Court of Law, it is unnecessary at the present moment to trouble you with categorical replies to the whole of the charges brought against them by the Gas Referees, and they have therefore directed me in this letter to confine myself to points which will neither in one way nor the other materially affect the question at issue raised by the company's present Bill.

In passing to more particular matters, it is necessary, in few words only, to advert to the opening statements in the letter of the 5th ult., which the Gas Referees designate as *historical facts*, which statements serve at the outset to show the very limited knowledge of the subject possessed by the Gas Referees, and the small pains they have been at to acquaint themselves with the history of gas purification. The directors are no tyros in the trade which they have undertaken, of gas suppliers to London. Guided by the constant study of the traditions of the past, as well as by the matured experience which the daily conduct of the oldest and the largest gas company in the world has given them, the directors, acting in the double capacity of trustees for their shareholders and servants of the public, have attained that "practical knowledge and experience in the manufacture and supply of gas" which is not to be acquired by the mere student, nor perfected by laboratory experiments alone; and which, though explicitly enjoined by the 29th section of the City of London Gas Act, 1868, as the qualification for at least *one* of the number, is, according to the thinking of the court, possessed by *no* one of the three Gas Referees.

The Gaslight and Coke Company Act, 1876, by the 30th section, previously recited, requires that "the Gas Referees shall from time to time ascertain with what degree of purity the company can reasonably be required to make and supply gas continuously, without occasioning a nuisance to the neighbourhood in which the works are situate, and shall thereupon prescribe and certify the maximum amount of impurity in each form with which gas supplied by the company shall be allowed to be charged;" and, acting in pursuance of that clause, and upon the best judgment which they possess in the matter, the Gas Referees have fixed such a standard of purity as is practically unattainable, except by the employment of lime as a purifying agent; and the directors now assert, and will at the proper time be prepared to prove, that "nuisance to the neighbourhood in which the works are situate" is, in the present state of scientific knowledge, unavoidable, if the requirements of the Gas Referees are to be carried out.

The Board of Trade will therefore observe that while the company are liable, under the general law of the land, to an indictment for nuisance, and to consequent penalties, if they *do* obey the injunctions of the Gas Referees, they are, under the 51st section of the company's Act of last year, liable to a penalty of £100 a week for every one of their

nine manufacturing stations if they *do not*. The inconsistency of such a position is at once apparent.

Up to the present time the company have implicitly obeyed the instructions of the Gas Referees, and the result has at times been an amount of annoyance to the public which the directors do not feel justified in disregarding. Since the complaints of nuisance first arose, the Gas Referees have, very properly, and in the exercise of their duty, repeatedly, and at all hours, with and without notice, visited several of the company's stations, and investigated the processes of manufacture and purification, with a view to detect, if possible, any error in manipulation to which nuisance might be attributed. They have in every instance received from the company's engineers the very fullest information and co-operation. They have from time to time made their own suggestions for the abatement of the evil. Those suggestions have, to the very last letter, and by the express injunctions of the court, been acted upon by the company's engineers; and not in the spirit, as insinuated by the Gas Referees, of a wish to frustrate them, but with the honest and sincere desire to render even the most unpromising suggestion a success. In no one instance has success resulted; and the Gas Referees, unable themselves to cure the evil for which they alone are responsible, are therefore driven to the course of laying at the door of the company's engineers a want of "proper skill and consideration."

"*Other processes*" than the use of lime purifiers, say the Gas Referees, "have been proposed which give great promise, and which probably only require energetic and skilful trial to come into successful use." Notably, and pre-eminently, among these "other processes" stands the process which, in deference to the expressed wish of the Board of Trade, the directors permitted one of the existing Gas Referees to make the subject of experiment at this station in the years 1874 and 1875. This experiment, which had the benefit of trial under the sole control, supported by all the "energy" and "skill" of the gentleman in question, underwent a variety of changes, chiefly from bad to worse—lasted during a period of nearly eighteen months—cost this company, at whose expense it was carried out, nearly £3000, and terminated in signal failure.

The directors would willingly have refrained from entering upon personal questions, but they cannot but remark the inimical spirit which characterizes the letter of the Gas Referees and its general inaccuracy of statement, as well as the personality indulged in by them at the expense of the company's engineers. The directors have, therefore, no alternative but to defend their own management and the ability of their scientific officers as they best may.

The Gas Referees know little of the constitution of the Court of Directors upon whose management they cast imputations, or they would be aware that Mr. Evans, the company's late engineer-in-chief, "whose great knowledge, ability, and experience are known to the Board of Trade as well as to themselves," now occupies a seat on the court, of which he is the trusted adviser, and who, from his additional experience as a former Gas Referee, is able to weigh the edicts of the present body of Referees, and estimate them at their full value.

The Gas Referees (although in dealing with this question they have not visited the whole of the company's stations, and have, therefore, had no sufficient, if any, opportunity for testing the attainments of some of the engineers whom they disparage) express their belief that "the company are at a considerable disadvantage in regard to their engineering." The company's engineers frankly and warmly confirm all that the Gas Referees say in praise of their former colleague, Mr. Evans; but the directors are bound, in justice to those gentlemen who are still in charge of their works, to state that they are not sensible of the disadvantage alluded to, nor has the engineering of the company in any way suffered since Mr. Evans accepted his well-earned seat at the court as a director of the company; and they accordingly challenge the Gas Referees to show results of working in any other company, metropolitan or provincial, superior to those which are achieved by the engineers of this company.

The Gas Referees are surprised "that a gas company supplying more than half of London has not some eminent responsible and active head engineer to direct and control their scientific and manufacturing arrangements, Mr. Evans no longer occupying this position," and they go on to lament "the absence among the company's existing engineers of any well-qualified technical head with whom they could communicate on the general problem." The directors are of opinion that in working out this principle they, on their part, may fairly urge the advantages which would arise were the number of Gas Referees limited to one instead of three, care being taken that that *one* should be "competent" and "practical." In effect, the complaint of the Gas Referees amounts to this, that of the nine thoroughly practical, experienced, and well-qualified gentlemen who act as engineers of the company's stations, those with whom the Gas Referees have taken the trouble to communicate at all on this subject are found to hold opinions of their own, which, although cordially endorsed by the directors, including Mr. Evans, unfortunately do not always coincide with those of the Gas Referees.

It is possible that, from the great and increasing magnitude of the company's operations, the appointment of an engineer-in-chief may one day become matter of expediency; but the directors, who deem themselves the best judges of the proper mode of conducting their own affairs, after more than once giving the question due consideration, have thought it well to refrain for the present from making such an appointment. It has not, however, occurred to them that any inconvenience, either to the company or to the public, can possibly result, notwithstanding the fact that, as

the Gas Referees very justly observe, "it is not their province to act as the company's engineers or chemical advisers."

As before stated, it is not the intention of the directors in this letter to occupy your time in the discussion of specific points of manufacture, &c., which will ere long be fully argued elsewhere. They will now only draw the attention of the Board of Trade to the following facts:—That in Paris, and, so far as they are aware, in every other city of the Continent, testing for sulphur compounds, other than sulphuretted hydrogen, is unknown; that out of the many corporations or local boards which are now supplying gas in England and Scotland, one only is subjected to any additional restriction; and (which is most significant) that a reference to the draft Bill introduced in the session of 1875, by the Metropolitan Board of Works and Corporation of London jointly, for themselves undertaking the supply of gas to London in competition with the existing gas companies, will show that the restrictions as to purity which they so labour to impose and enforce upon this company are, when they themselves are in the case, conspicuous by their absence.

Witness: We did not attempt to write a reply to that document; but there was one point in it which we thought might need explanation, and we endeavoured to explain it.

The CHAIRMAN: I should say that last letter was not a judicious way of asking a favour of the Referees.

Mr. RICHARDS: You will remember, sir, the letter to which it was a reply.

Mr. POPE read the explanatory letter from the Referees to the Secretary of the Board of Trade, which was dated April 20, 1877:—

We beg leave to acknowledge the receipt of a copy of letter addressed to you by the secretary of The Gaslight and Coke Company on the 7th inst. We notice with regret the hostile spirit manifested towards us in that communication, and as we believe this hostility to arise from a misapprehension of some remarks in our letter of March 5, we desire to use the present opportunity of rendering our meaning unmistakeable.

In witnessing the discharging of the purifiers at those stations regarding which complaints of nuisance had been made, we were struck by the fact that in no two cases was the mode of working the same. At one station the actual emptying of the purifiers was conducted under cover, and no unpleasant smell escaped; but the refuse lime was afterwards shot into barges with no protection from the wind, and thus a decided nuisance was created. At another station the conveyance of the refuse lime into barges was effected under cover, and without nuisance, but during the actual emptying of the purifiers the foul substance was freely exposed to the action of the wind. At other stations no precautions whatever were taken either in emptying the purifiers or in removing the lime.

It seemed to us that if the precautions which we witnessed at different stations were properly combined, complete success would be the result; and we also thought that the cause of the observed want of unity in the methods of dealing with the same problems at different stations might be justly, and without offence, referred to the absence of a chief engineer entrusted with the power of bringing into general use whatever special ameliorations the experience or ingenuity of the superintendents of the different stations had devised. It was very far indeed from our intentions to indulge in personality at the expense of the company's engineers, or to disparage them; nor do we believe that any language of ours is fairly open to this interpretation.

We know how small a place such a question as that of discharging a lime purifier can occupy in the thoughts of the busy manager of large gas-works, and we are quite prepared to accept the statement of the secretary, that there is not any other company, metropolitan or provincial, able to show results of working superior to those which are achieved by the engineers of The Gaslight and Coke Company.

That letter was signed by Mr. Vernon Harcourt and Professor Tyndall, and the following, dated May 5, 1877, was subsequently written to the JOURNAL OF GAS LIGHTING by Dr. Pole:—

Having been abroad when the letter from the Referees to the Board of Trade was written, I wish to add my individual disclaimer of any intention to cast imputation on my professional brethren, the engineers connected with The Gaslight and Coke Company. I have a high opinion of some of these gentlemen, with whom I am personally acquainted, and I know nothing, and would certainly insinuate nothing, to the disparagement of any. I regret that such an impression should have existed, and it can only have arisen from a misunderstanding as to the sense of our communication.

By Mr. ROUND: We are all agreed that oxide of iron will not produce the degree of purity which is attainable and ought to be attained. It is also agreed that by lime a greater perfection can be obtained. In fact, in the present state of science, it is the only known means in use. That being so, the next question is how the foul lime is to be disposed of.

Mr. ROUND: Upon that, I understand that Mr. Evans says the ventilation of the foul lime is not new to him; that he adopted it at the Berlin

works, I think, 38 years since; and that it would probably entirely get rid of the nuisance from the foul lime.

Witness: That appears to me to be an important statement, coming as it does from Mr. Evans, the former engineer, and now one of the directors of the company.

By the CHAIRMAN: I do not know that any process for removing sulphur compounds out of gas, except the ordinary lime process of which we have heard, has been successfully brought into use.

Mr. ROUND: I think that is admitted on both sides.

Mr. MICHAEL: That is a part of our case, certainly.

The COMMITTEE: You contemplate other methods; you say that other methods have been suggested?

Witness: That is a matter which rests with the gas companies to bring into use. There are others which, I believe, might succeed.

Mr. ROUND: What is the particular method which you think might be adopted?

Mr. POPE: I know what it is now—that is, what is in operation at Fulham, because the witness speaks of the overheating during that process, and the consequent generation of stench by naphthaline.

Mr. ROUND: That is the practice at Fulham. It seems that you and Mr. Evans are at one as to the efficacy of the system at Fulham?

Witness: I wish to say absolutely that I quite agree with the views which Mr. Evans holds as to this process, and I share his belief in its efficacy. I have seen the system in operation at the Fulham works, and I believe that its introduction is a most material contribution to the means in use for getting rid of the foul lime without creating a nuisance.

By the COMMITTEE: The peculiar system which I say is an improvement, as worked at Fulham, consists in drawing the air downwards through the lime before it is removed from the purifiers; and the advantages gained by it are—first, that the foul gas, as it is called—the crude gas with which the purifier is charged—is drawn out of the purifier by that means. Then the air which passes in carries away also the sulphuretted hydrogen dissolved in the water when the lime is damp, and by the oxidation of the lime which goes on to some extent, the material is rendered less offensive than it is when removed directly. I do not know any reason why that plan should not be adopted in the other works of the company. My opinion is that it ought to be adopted everywhere.

Examination resumed: The system adopted at Fulham is in use at some of the other works, but I can hardly say which; it has only been brought in quite recently.

Mr. ROUND: Do you know what processes there are, other than this, that are in use at the other works?

Witness: Some evidence was given recently upon that point by Dr. Frankland. There is the process which is pointed at in the letter of Mr. Phillips, which was read to the committee—the process that was tried at my suggestion at the Horseferry Road station of the company. It is impossible to say, until the process is actually in successful use, that it can be used successfully; and the committee well understand the difficulty which there is in this matter. We believe that, if the company would do their best with the object of reducing the amount of sulphur in the gas, they might develop other processes besides the one of purification by lime; but we cannot say positively, because, from the nature of the case, the matter is wholly in the hands of the company. A considerable sum, though less than that named in Mr. Phillips's letter, was expended by the company on a trial of the process which I recommended. Dr. William Siemens devised the apparatus which was employed, and I was responsible for the chemical part of it. That process consisted in bringing the gas, already purified from sulphuretted hydrogen, into contact with heated surfaces. I had ascertained, and others had observed before me, that the effect of this was to convert the bisulphide of carbon in the gas, which cannot be removed by any agent except the sulphide of calcium, into sulphuretted hydrogen, which is removable by oxide of iron. I had found also, by many experiments, that this could be effected without injury to the illuminating power of the gas. What remained was rather an engineering than a chemical question. To accomplish this on a

large scale, and to construct an apparatus by which a large volume of gas could then be treated, Dr. Siemens arranged an apparatus, as far as I can form a judgment, very ingeniously contrived for this purpose, and that apparatus was in use for some months. As commonly happens in experimental works, the apparatus was not perfect in particular, the plates which should have held in the gas which was generated cracked, and a large quantity of it escaped. The burning gas passed through the tubes of the apparatus, by means of which the heat was applied to the remainder of the gas; the temperature became unmanageable; the materials with which the heating apparatus was charged became coated with a deposit of carbon from the gas, and their purifying effect was thus impaired. For some time (on two occasions, for ten days or a fortnight together, a volume varying between 10,000 and 20,000 cubic feet per hour was purified by the apparatus; but the leaks increased, and went, as Mr. Phillips's letter says, from bad to worse, and the experiment was ultimately terminated, not, I consider, because the process failed, but because of the accident that had happened to the apparatus. The apparatus was not set up in order continuously to purify the gas that was being manufactured; it was only an experiment, and aimed at the discovery of practically purifying gas without injury to its illuminating power, and that, I believe, the experiment did demonstrate. I have since continued laboratory experiments of the same kind, and I have gained further knowledge upon the subject. My belief is, that if the company were willing to make a trial of this process, it would be practicable to overcome the engineering difficulty, but more than I have done in the matter I cannot do; it must rest with the company to try it or not. I tried every experiment myself during many years; and these large experiments were made at the expense of the company, at the Horseferry Road station, during the autumn of 1874 and the spring of 1875.

Mr. ROUND: Having shown certain good results, do you wish to convey to the committee that the company ought to have tried the experiment on a larger scale, and to have continued it?

Witness: I should be glad if they were willing to do so, as I think it offers them an alternative to the use of lime.

By the COMMITTEE: The mechanical nature of the arrangement consisted in a regenerative furnace, in which the regenerative principle was applied by causing heated gas to pass down through a chequer work of pebbles and brick, to which it gave up its heat before leaving the apparatus, and then by means of a valve reversing the current of gas entering the apparatus, the gas passed through the same brick chequer work, took up the heat given out by the former portion of gas, and so, by reversing the valve, each portion of gas was heated without the heat being carried out of the apparatus, and undoubtedly with a very great economy of heat. The quantity of fuel employed in working the apparatus was insignificant.

Mr. ROUND: From all the observations that you have been able to make, and the experience which you have acquired during your term of office, and the frequent visits that you have paid to the works, and so on, are you satisfied that even if they adopt carefully the present mode of purifying with foul lime, it could be done without creating additional nuisance?

Witness: Personally, I feel no doubt upon the matter.

Examination resumed: I have a model made here illustrating the mode adopted at Fulham. That [pointing] represents the exhauster, which is used for pumping air through the lime after one purifier has been shut off from the rest of the purifiers, and is no longer used for the purification of gas. There are some taps on the top of the apparatus which are opened, and then the exhauster is set to work. The air carries down with it a portion of the gas, which the purifier still contains when shut off. The air is then driven through this arrangement, which is a brick trough, also having perforated sieves on which are placed layers of oxide of iron. The sulphuretted hydrogen which the crude gas contains, and which, of course, is carried off from the lime in the purifier, passes up through this oxide of iron, and there the sulphuretted hydrogen is removed, while the air in the gas, which is quite inoffensive, escapes. By

the continuance of this process for some time the lime becomes comparatively inoffensive. There were one or two suggestions which I ventured to make to the superintendent of the works on visiting him and seeing this process. One was, that as far as possible the surface of the lime exposed at any one time should be reduced. One of the complaints of which the committee have heard is, that the difficulty is far greater on a large scale, because, with the large purifiers that are used, a large surface is exposed, and it seemed to me, though I am only an amateur in such matters, that this large surface might be reduced by having the arrangement here represented, by which one portion of the lime could be covered over when the lid was raised, so that when they were shovelling the lime into their bags no offensive smell would escape from the part covered with the sacking.

The COMMITTEE: Do you mean that this does not entirely purify the lime before it is removed, but that it only contributes to the purifying of it?

Witness: It only contributes to it; the air might have passed for many hours, and the lime would even then be in some degree offensive when taken out. Something depends upon the condition of the lime—how far it is damp or dry. If the lime were damp, I feel no doubt that drawing the air down to dry it takes out the sulphuretted hydrogen. I believe that two or three hours passage of air through the lime would generally make a considerable difference in the degree of offensiveness of the lime. I also suggested that this down current of air through the lime should be continued during the operation of discharging the purifier. That, I think, is important, especially when a part of the surface is covered up—it produces a distinct down draught through the substance, and makes it much less likely that any effluvium or fine particles should be blown away from the surface. When this operation has been going on, I have made observations round about. I mounted here [pointing to the model], and stood there for some time, and observed as carefully as I was able the degree of smell which came from it; and my conviction is, that when the process, with Mr. Evans's improvements, is rigidly carried out, nothing can escape that is offensive to the neighbourhood.

The COMMITTEE: What does this represent [pointing to the model]?

Witness: I might explain this also, as it is a very important part of it. The lime, when it is dug up from the layers, is shovelled into bags, which are carried on men's backs up a plank laid at the side; then it is tilted over and falls through a trap into a waggon, which runs on a tram. As soon as the waggon is full, it is covered over and runs to another point, where a second hood is let down over it, and then, by levers which stand out at the side of each of the waggons, the bottom of it is allowed to fall out, and the lime drops, still protected, into a barge, and there it is covered over. This is an arrangement which, I believe, was contrived by Mr. Kirkham, and it appears to me to be very well designed for avoiding any nuisance in that operation.

Mr. ROUND: How far has the sulphur been removed from the lime by this process?

Witness: I should think very little sulphur is removed in the process; the effect of the action of the air upon sulphide of lime is not to remove the sulphur, but to oxidize it, and as far as it is oxidized it is inoffensive.

At all events it removes the sulphuretted hydrogen?—It does rather more than remove the sulphuretted hydrogen which hangs to damp lime; it oxidizes the lime sufficiently, converting the sulphide of calcium into sulphate of calcium, and so renders the lime less liable to give sulphuretted hydrogen off when exposed to the moisture of the carbonic acid of the air.

Examination continued: The principal defect which there seemed to be in actual working at Fulham was that there is one of the exhausters only in use, and that is in connexion with three distinct sets of purifiers, two of which are emptied simultaneously. Now, since the same pump is used to pump air downwards through each, the two being simultaneously entered, and since the rate of discharge of layer after layer will not proceed simultaneously *pari passu*, it must frequently happen that the down draught is only operating in the case of one of the two purifiers, and in

that case the other is without the protection which it furnishes. I think it would be necessary that there should be a pump to each, which there would be no difficulty in having, as they are not very expensive.

Mr. POPE (in cross-examination): The words in the Act, "A practical knowledge and experience in the manufacture and supply" point to somebody who has been engaged in that manufacture and supply. Which of your number satisfies that requirement?

Witness: I think it may be taken that my colleague, Dr. Pole, has a much larger experience than I have had. At the same time, I have been occupied on practical matters connected with the manufacture and supply of gas for some seven or eight years, and though one is unwilling to claim for one's self any particular knowledge, I believe I am not without that knowledge, although I have not been actually engaged in the manufacture and supply of gas. A great part of the correspondence has been undertaken by me, and I have had special work in connexion with the purification which the Board of Trade asked me to undertake. I have visited all the stations of The Gaslight and Coke Company, with reference to the complaints of nuisance which have arisen—Haggerston, Pimlico, Bromley, and Fulham especially. The reason we made a variation in our requirements for winter and summer was because the same amount of purifying material will effect a greater purification when the volume of gas passed through it is less, and the volume of gas passed through is less in summer than in winter.

Mr. POPE: I may take it that, in your judgment, the quantity produced in relation to the purifying apparatus ought to modify the requirements of purity?

Witness: Or else the amount of purifying plant, as it is termed, should be increased. If the make of gas is to be spoken of as indefinite, the amount of lime used should be indefinite also; in other words, if it be an inevitable nuisance, it will be an increasing nuisance.

Supposing the lime process not to be used, but a return to be made to the oxide of iron process, what amount of sulphur impurity would be left, or should you expect, in gas, supposing the oxide of iron process to be perfectly and carefully carried out?—I think it would average about 33 grains in 100 cubic feet.

Then the lime process is rendered necessary in order to get rid of 13 grains in 100 cubic feet, according to that calculation?—More than that.

No; you prescribe 20, and if there was no lime used 33 grains would be the result; the lime process is therefore rendered necessary to get rid of those 13 grains?—I spoke, not of the maximum, but of the average; you are comparing the maximum with the average. I think what the company have named—40 grains—is the right maximum.

We may take it that it is to get rid of from 15 to 20 grains, according as it is winter or summer, that the lime process becomes necessary?—Yes.

Do you still think that "much is to be said in favour of the view that the presence in gas of the small amount which lime purification removes is of no great consequence to the consumer"?—I certainly think so. I have heard a great deal said upon that subject within the last two weeks.

I do not want to commit you to an absolute statement; but, taking the whole matter—the information you gain from what you have heard and read, and what other chemists are doing and saying, and so on—what do you say now as to the inclination of your opinion that it is of no great consequence to the consumer to get rid of the small amount of sulphur which lime purification removes?—I would say of no great consequence.

It comes, therefore, does it not, to be a question whether you should relax your requisition of 20 grains, supposing the carrying out of the lime purification, or some other process, creates a nuisance?—Yes; I think that unless we believe that by some means gas could be purified without the creation of a nuisance at the maxima that we have named, it would be our duty to fix a higher maximum—such as 40 grains.

You would not, I suppose, insist upon your maximum simply because hereafter some means may be discovered?—No.

It would be quite time enough to fix your maximum when it is?—Certainly.

I have read with great interest what you have done with regard to the heating process you speak of, but you would hardly say that that, at all events, should be taken into account to-day as a process of purification?—I think only as illustrating the likelihood that, besides the process actually in use, if the obligation is continued upon the gas company to purify their gas beyond the removal of sulphuretted hydrogen, other processes besides the lime process may come into use.

Cross-examination continued: We have not maintained our maximum at its present figure in order to stimulate the company. We fixed the maximum simply because we believed it was a maximum which was practical, without the infliction of injury upon the neighbourhood. When I first visited Fulham the whole arrangement for the removal of lime from the purifiers was already in operation. The other point I have named—that is to say, the covering over of a part of the lime when it was exposed, and the continuance of the down draught after the raising of the lid; and another point, which I have not mentioned yet—namely, damping the lime when it was found, on lifting the lid of the purifier, that it was in a dusty condition—those matters were adopted at my suggestion. My last visit to the Fulham works was towards the end of January.

Mr. Pope: Did you at that time carry with you any test, such, for instance, as a bit of blotting-paper in your hat, which was saturated, with a view to ascertain whether there was sulphuretted hydrogen given off, notwithstanding all these precautions?

Witness: I placed nothing in my hat, but I am very familiar with the smell of sulphuretted hydrogen, and could detect a very little at once. I do not think that the bad smell of the refuse lime is merely the smell of sulphuretted hydrogen, but I do not know what it is. It has never produced any bad effect upon myself except the dust, which is certainly unpleasant to the eyes when it is blown from the purifiers; and I have also found that the smell of the refuse lime is extremely persistent when one's clothes have been covered with this dust. I think that dust would travel half a mile on a windy day. On a wet, soft, muggy day it would not travel so far.

Mr. Pope: How do you account, if it be the dust, for the fact that everybody complains of it more at a distance in wet muggy weather than they do when the weather is windy, or the atmosphere clear?

Witness: I think what they complain of is the smell of the gas-works. I do not think most of them can distinguish between the portion of the bad smell due to refuse lime and other smells.

What is your opinion with regard to the smell of the gas-works? Is it better or worse during foggy days?—I think it is worse immediately in the neighbourhood of the purifiers, but probably the smell would not be carried so far.

I do not say there may not be a nuisance from the dust; but assume that it is proved that the nuisance is worse at a distance, under atmospheric conditions less favourable to dust travelling, would you, as a scientific man, then abandon the dust as the cause of the nuisance, and look for something else?—I think it more likely, if it were found that the nuisance at a distance was greater on still days than on windy days, that it would be due to some gaseous emanation, and less likely to be due to the dust.

You say you doubt its being sulphuretted hydrogen; what other gaseous emanations would you suggest?—Smells which have never been analyzed; I think I may say that positively. It is not known what substances produce the impressions of smell which you receive in the neighbourhood of gas-works, but there can be no doubt that they are very various.

Have you any experience with regard to this process of ventilating, as you call it—drawing air through a chamber for the purpose of purifying lime?—Yes; I have seen it done occasionally.

What special danger attends the use of that process?—The heating of the material, which I believe has been found to reach such a point that the sulphur in the mixture of the gas and air might inflame and explode.

Explosion is the danger. Do you know that, in point of fact, explosion is found to result where the process has been carried on to an undue extent?

—I have heard of explosion resulting, and I have seen an arrangement at Fulham for the purpose of avoiding that. I might add, however, that I think it should not be difficult, as the exhauster gives a perfect power of controlling the current of air, so to regulate it as to prevent the temperature reaching this point.

Would there be a tendency in this ventilating process to carry over into the oxide of iron other sulphur compounds besides sulphuretted hydrogen?—I have made the best experiment it is possible to make. I have stood by the side of the brick trough holding the oxide of iron when the ventilating process was in action, and I have observed that on the surface of the oxide no smell, or next to none, was perceptible.

Cross-examination continued: In one of my letters I suggested that the purifiers might be under a shed or cover, and that that would reduce the nuisance, and I believe the plan is adopted at Pimlico. I believe the source of the nuisance is not the purifiers in the shed, but the emptying of the lime, as I saw it tipped from the carts in the Grosvenor Road into the barge. All the smell that lime can possibly give off arose when the contents of the carts were tumbled down a distance of between 20 and 30 feet. The lime was shot out in a solid stream from the tail of the cart into the barge.

Mr. POPE: The main difference between us comes to this—you rather attribute the nuisance to this dust than the sulphuretted hydrogen?

Witness: I think a great deal depends upon the condition of the lime when the purifier is being emptied. Sometimes it is extremely wet; and in that case, unless the ventilating process has been in use, the water in which the lime is damped will contain a considerable quantity of sulphuretted hydrogen; and I believe also that the lime, when damped, will give up the sulphuretted hydrogen more readily to the air than when it is dry. Of course, also, when it is damped, no dust will be blown from it; therefore the cause of the nuisance may vary according as the lime is damp or dry, and I believe it does so vary.

You doubt whether it is sulphuretted hydrogen at all?—No, I have not thought that; but I do not admit that if the lime is damped the smell coming from it must be sulphuretted hydrogen. I have said that the smell is of a complex character.

It is not merely a question of smell. You, as a chemist, would be able to recognize sulphuretted hydrogen, not only by the smell, but by the physical results?—As a chemist, I might recognize it by the chemical results.

There are well-known physical symptoms, the result of inhaling sulphuretted hydrogen, are there not?—I have never suffered from it. I know the smell very well; but a smell may be disagreeable without resulting in suffering to health.

I was speaking of noxious, unwholesome, and unhealthy?—I have never heard of any evidence in the sense you use the word "noxious"—that is to say, injury resulting from the exposure of refuse lime at gas-works. If the air contained a sufficient portion of sulphuretted hydrogen, no doubt it would be poisonous. I have never seen a case of injury by sulphuretted hydrogen.

By the COMMITTEE: Between two and three years before I was appointed a Referee I was engaged in experiments at the Oxford Gas-Works, and I spent a great deal of time upon those works, during which time I became familiar with all the ordinary operations of gas manufacture. I was making those experiments on my own account. Some questions had been suggested to me by a friend of mine, who is the son of the manager of the Cheltenham Gas-Works, and becoming interested in the subject, I engaged in those experiments. I suppose, during a period of six months, I was there about every other day. I was engaged partly at the gas-works and partly also on similar experiments upon a smaller scale in my own laboratory. During that period the chief part of the leisure which I had for scientific work was devoted to experiments in connexion with gas purification, or to observations of the illuminating power of gas; and I have also undertaken experiments on a larger scale at gas-works. My opinion has always been that the small amount of sulphur which the lime purification removes is of no great consequence, but I do not consider that is a

[illegible]

The Commissioner. You said that after the year of practice by some of them, about 40 grains was the average employed?

Witness. Not on the average but the maximum. The present relation from 40 to 20 grains depends entirely on the use of the lime process.

Supposing the lime process had not been discovered, if that were put out of consideration altogether the process of purifying by passing over heated substances is not of so well ascertained a character that you could reduce it from 40 grains to any other standard?—I think it should be understood what the difficulty is. The introduction of this rests with the gas company. They would prefer that they should be freed altogether from the obligation rather than that they should have the chance of risk and failure that there is in the introduction of a new process.

He should, supposing it rests with you to determine the maximum, and that you had settled in your own mind that 40 grains was the maximum with the oxide of iron process. The lime process I put out of consideration altogether, but there is this process of passing gas in contact with heated surfaces, which would admit of further purification if it were a practicable plan. Do you consider that it is so far a practicable plan that you could at the present moment reduce, or that you would be justified in stating that you could reduce the maximum from 40 grains to any other figure? No, I think if it were not for the existence of the lime process, and the possibility of conducting the lime process without a condenser, we should be obliged to prescribe a maximum of 40 grains.

Mr. Merivale. I should like to be allowed to state that we are exactly on all fours with Mr. Vernon Harcourt as to that, and I say so with a view of saving any expenditure of time upon the points on which we are in accord.

The Commissioner. It was entirely in the interest of your side that the question was put.

Mr. Merivale. It has entirely cleared up the matter, because that is

exactly the view which we take. I am obliged to Mr. Vernon Harcourt for having so exactly stated the position, and in it we are entirely in accord with him.

By the COMMITTEE: I heard the evidence of Professor Church, Professor Barff, and other witnesses in the last case, and I feel no doubt that there is sulphuric acid produced; but my own belief is that it is only a small portion of the sulphur which passes at all into the air which is converted into sulphuric acid in the air of a room; and I thought the experiments which have been instituted by Dr. Odling and Mr. Russell, as well as the calculations upon the subject submitted by Dr. Odling, were very instructive. I attribute the destruction of pictures and of bookbinding more to heat and dryness than to any sulphur compounds in the gas. As to the deposit of sulphate of copper, that undoubtedly occurs. I have myself collected from the surface of a brass tube, which was placed over a gas-burner with the intention of carrying off some of the products of combustion, a considerable quantity—half an ounce or more—of what I afterwards analyzed and found to be crystals of hydrated sulphate of copper. That was undoubtedly produced from the fact of the sulphur impurity. I think there is really no difference of scientific opinion upon the point that some sulphuric acid is produced by the combustion of gas containing sulphur. I quite agree in the opinion that, if the process of purification by lime for these sulphur compounds can be conducted without a disagreeable smell being produced, it would be worth while to continue that process. It appears to me to be purely a question of cost. I believe that the difference in the cost of purification down to the limit of from 20 to 15 grains of sulphur, and down to a limit of 40 grains, would not exceed something like 2d. in 1000 cubic feet, and my opinion as to the likelihood of some injury to books, furniture, pictures, and curtains, resulting from the deposition of this minute quantity of sulphuric acid upon them, is sufficient to make me think the difference of price worth incurring. I feel for myself, if I may state it in that way, that if I had the alternative of burning in my house either of the two samples of gas—either the one with the maximum of 40, or the one with the maximum of 20 grains—and I had to pay the 2d. more for the purer gas, I should choose the purer gas, and pay the extra 2d.

By Mr. O'HARA: I am aware of the fact that in 1876 the Chartered Gas Company came to Parliament for a new Act, and I understand that that Act of Parliament was the result of a negotiation between the company, the Board of Trade, the Metropolitan Board of Works, and the Corporation?

Mr. O'HARA: Was there any greater difficulty in the summer of 1875, and in the summer half of 1876, than there is now? or is there any greater difficulty in the summer half of 1877 than there was in the summer half years of 1875 and 1876, to comply with your prescribed maximum?

Witness: Only such as would arise from the continual increase in the amount of gas supplied. I am not aware of any special circumstances at present which make it more difficult for them to comply with our prescribed maximum than there was in those two summer half years, except the difficulty which has been pointed out in the disposal of larger quantities of refuse lime; and, if the area on which it can be placed is small, that difficulty must also increase continually. That would be a question of situation, also of expense. When The Gaslight and Coke Company's Bill of 1876 was passing through Parliament, I was, as a Referee, consulted about the change in the mode of inflicting the penalties. The gas company represented that it was a hardship that they should be liable to a penalty for the impurities of one day. I advised the Board of Trade that it would be fair to substitute an average for the result of one single day, and I believe I suggested to Mr. Phillips the actual wording of the clause. At that time, when the Bill was settling the capital and the initial price, and all sorts of matters connected with the company's affairs, no representation was made about the impurity question.

Mr. CRIPPS: You say that this is really a question of expense, so that, in fact, to relax the conditions, which my learned friends by their Bill are endeavouring to do, would be practically increasing to the consumer the initial price of gas? Do you follow me?

Witness: I follow you; it would make a difference of that kind.

In fact, you say it costs about 2d. per 1000 feet to purify the gas according to your rules?—I think the difference would be effected for that sum.

Putting that as the maximum; then we see the price of gas was fixed at 3s. 9d. per 1000 cubic feet, and at that time Parliament left you to prescribe the degree of purity or the maximum of impurity which was to be found in the gas?—Yes.

Supposing this 3s. 9d. to be the price of gas, purified according to your rule, that would be putting the price to the consumer of unpurified gas at 3s. 7d.?—If I am right in the figure, it does not represent any calculations of mine, but it is the difference that I have heard stated.

If you call the price settled by the Act of last year 3s. 9d., under this Bill 3s. 9d., *minus x*, ought to be the price if the conditions of impurity were relaxed?—That seems fair.

In 1876 the degree of purity that you prescribed was identical to that which you are prescribing at the present moment?—Yes; we have made no change for two years.

Had the gas company had the experience of 1875 and 1876 when they got their last Act of Parliament?—That is so.

May I take your evidence generally to be this, that the process required to be carried out by the company can be carried on without producing a nuisance?—I believe that to be so.

You believe that the purifying material, after it is used, can be effectually purified?—It gradually changes into an innocent substance by standing.

Cross-examination resumed: I have heard no evidence as to the particular explosion that has been referred to, but I can easily understand how an explosion would arise if air is drawn through so rapidly as to produce a rise in temperature up to the inflaming point of sulphur, which is not very high. I do not think the question of purification has been merely a matter of cost. I have no doubt that a great deal of annoyance has been caused to managers of gas-works, both by the difficulties which there undoubtedly are in the operation as it has been conducted—I think in many cases without the precautions which might be used—and, no doubt, the complaints of nuisance, so far as they are due to this cause, have been another source of annoyance. I do not myself (but I am only giving an opinion) consider that to gas managers generally it is simply a question of cost.

Mr. O'HARA: That is not quite an answer to my question. Supposing they had understood that, provided they were simply remunerated for any extra expense to which they were put in arriving at this degree of purity, so far it would be a question of expense?

Witness: Yes.

But being secured from loss and paid what they wanted, do you really think that you would have heard of all these difficulties?—I cannot say certainly.

Do you not think that the extra price would have removed a great many of those difficulties?—I do not know that I can form a judgment of what their motives would have been.

By the COMMITTEE: I have often considered this matter with my colleagues, and I believe they agree with my views.

Dr. *William Pole*, examined by Mr. ROUND.

Mr. Vernon Harcourt hardly correctly answered when he said I was appointed a Referee at the same time as himself, because I was appointed two years earlier—when Mr. Evans retired. At that time Mr. Evans's colleagues remained with me, and we formed the board till 1872, when they were not reappointed, and Mr. Harcourt and Professor Tyndall were appointed in their places, so that I am two years older in the appointment. I have been in the room the whole time, and have heard Mr. Vernon Harcourt's evidence, and I concur with what he has said. We have acted together all through, and we have been entirely agreed in everything that has been done.

The COMMITTEE: Is there anything you wish to add to what he has said?

Witness: No; except that there was a good deal of correspondence,

and a great many events occurred between the time when we first fixed the maximum and the time when he began to give the historical account. The first act of our predecessors, in August, 1872, was to give notice of their intention to fix a maximum of 15 grains for Bow and Beckton, where lime could be freely used, but for other works they postponed the maximum. Our first step in the matter was to confer with the engineers of the gas companies. We knew there was a strong feeling that the sulphur must be reduced, because it had been a matter constantly discussed between our predecessors and the authorities of the public and the gas companies. It was a matter forced very strongly upon our attention, and since our predecessors had resolved to fix a maximum which had never been done before, it was, of course, a matter of serious consideration for us whether we should carry out that step. Accordingly, on the 5th of September, 1872, five days after our duties began, Mr. Evans and Mr. Harris, the then engineers of the Chartered Company, attended, at our request, at our office, to discuss the subject, and after a long and full discussion a decision was come to, which I will read an extract from the minute-book to explain:—

Mr. Evans and Mr. Harris attended, and were introduced to the Referees; the subject of the sulphur maximum was fully and lengthily discussed with them. It was agreed that the following passage should stand part of the forthcoming Instructions:—"For gas made at Beckton and Bow, where lime can be freely used for purification, the maximum amount of sulphur allowable has been fixed for the present at 20 grains per 100 cubic feet of gas; for gas made at other works no maximum has yet been fixed, and meanwhile the quantity shall simply be recorded." Mr. Evans stated that he consented to this maximum, and would use every endeavour to adhere to it; but he wished a note made to the effect that he should hope for protection in case of a disappointment. Mr. Evans wished the attention of the Referees to be called to the great expense of lime purification as compared with that effected by oxide of iron. Mr. Harris called attention to an increase of sulphur as the quantity of gas made increased.

The maximum was accordingly fixed, as has been already explained to the committee. This proposal, as far as we could ascertain, appeared to work very fairly, and the sulphur was kept well down; and I do not remember any complaints from the company that there had been difficulty. Our attention then was directed to the purity of the gas supplied from the other works. Complaints were urged upon us of the sulphur it contained; I need not read them, but we knew that the attention of the public was drawn to it, and we had very strong complaints from private parties addressed to us. We made ourselves acquainted with the experience that had been gained elsewhere as to the use of lime in various towns, and we inquired as to certain cases where lime was used in London. At Pimlico, for example, lime had been used. I have the minute here which will show we found that to be the case:—

On the 7th of February we went to the Horseferry Road and saw Mr. Brothers, the superintendent of the station. We went in with him to the Equitable works at Lupus Street, and looked over them. About four-fifths of the gas is purified by oxide of iron only, for one-fifth of lime is used in conjunction with the oxide. The latter is much reduced in sulphur, and improved in illuminating power. We also noticed that at one gas-work in the heart of London, (Blackfriars), belonging to the Chartered Company, the sulphur had been kept very low by certain precautions, as we believed, in the management of the works. The result of our consideration was a conviction that we might safely fix a maximum for the urban works; but before doing this, we thought it right again to confer with the gas engineers most interested, and on March 13, 1873, we had an interview with Mr. Brothers, one of the superintendents.

I will read the minutes of what took place:—

Mr. Brothers attended in support of his letter of the 11th of March, remonstrating against the assumed intention of the Referees to fix a 20-grain sulphur maximum for Lupus Street station.

He stated that though he would accept this maximum for the summer months, he should not be able to do so for the winter, as, under the large make of gas, his purifiers had not sufficient area to allow lime to be used in sufficient quantity, for if the area was limited under a heavy make of gas, the pressure necessary to drive the gas through became too heavy, and blew the seals. The disposal of the foul lime caused inconvenience; but he did not attach so much weight to this, as it might be got over with care and proper arrangements. At present about half his gas was purified by lime (bringing sulphur to say 10 grains) the other half by oxide say 30 grains, average 20 grains. He was quite willing to accept 20 grains for Lupus Street and Kensal Green, for the summer, on the understanding it was to be reconsidered for the winter. The Lupus Street works were never intended for dry lime; they were limited for space, and

their space could not be extended, Dry lime purifiers required so much more area than oxide.

On the 21st we saw another of the officers of the Chartered works—Mr. Mann—who had the management of the works, which are now abandoned, at Blackfriars. Our minute of the 21st of March is—

Mr. Mann attended and consented to a sulphur maximum of 20 grains for the Blackfriars works.

Upon this encouragement we decided to fix the maximum of 20 grains for the urban works. But we thought it would not be right to do it at once, and we gave the companies three months notice that it would come into force on June 30, 1873. Of course we received some protests, which were to be expected. It was our unpleasant duty to put some pressure upon the companies, and it was natural they should resist it as much as they could; but our duty was to convince ourselves that we were acting only fairly. We received several protests against any maximum being fixed, principally on the ground that the works would be likely to find a difficulty in avoiding the nuisance. I have the dates of several letters, and our answers, which can be read or not, as the committee may decide. Then we considered the matter very carefully. We had an interview with the Board of Trade, and we made ourselves acquainted with the experience in other quarters. I should say that during that time we had used every endeavour to find out what was done elsewhere, and I have a great number of memoranda of what was done in different towns which we visited, showing, at any rate, that we took all the pains we could to inform ourselves. We also visited some works where experiments were being tried, because the companies, very rightly and properly, before the date came when they would be called upon to adhere to the maximum, began to use the lime, to try what would be the effect of it. The 30th of June approached, when our maximum was to come into force, and then the companies remonstrated, and took a good deal of pains to show that they were not ready—the committee will have read that. We saw the justice of their complaints, and relaxed the maximum five grains on the 30th of June, for which the companies expressed themselves very much obliged. Then came other correspondence, complaining of the nuisance at some of these places, and every complaint was investigated and answered. The letters and answers are at hand, and can be produced if desired, showing that we spared no pains to inform ourselves as fully as we could. On the 3rd of July we had a letter from the authorities of the City, on the other side, complaining in strong terms of the relaxation that we had made, and that we had not kept the maximum so low as we ought to have done. The Corporation were constantly complaining of us, and in a letter sent to the Board of Trade, a very strong complaint indeed was made that we were not doing our duty, and not keeping the maximum so low as we ought to have done. They even went so far as accusing us of being unfit for our duties, because we had not pressed the companies more. Afterwards, on the 30th of June, at the urgent request of the companies, we released the maximum of five grains, and we received the following letter:—

Guildhall, E.C., July 23, 1873.

Gentlemen,—I have to inform you that the circular issued by the Gas Referees, with respect to the maximum of sulphur as proposed to be fixed by you for the winter months at gas-works other than Bow and of Beckton, has been laid before the Gas and Water Committee of the City of London, and they have directed me to state that they feel much disappointed at the change proposed, as they had been led to expect that the maximum would have been diminished at all the stations rather than increased at any; the more especially as in their opinion ample time has been given to the companies for the necessary alteration in their apparatus for purification. I am further to call attention to the great desirability of diminution in the quantity of sulphur in gas from the deleterious effects it produces, not only upon substances exposed to its influences, but also to the health of those inhabiting the rooms in which gas charged with it is burned.

I am, &c.,

JOHN B. MONCKTON, Town-Clerk.

Our answer merely stated that we had done what we thought just, and could not do more. There were then some further complaints, which were investigated and answered. There were also some complaints in 1874. On

April 23, 1874, there was a very long communication from the town-clerk to the Board of Trade, complaining of our conduct generally as being too lax upon the subject of the sulphur maximum. That letter contained the following passage :—

The committee have, however, reason to believe from the reports received of the amount of the sulphur impurity, as tested at Beckton and Bow, that there is not now that care and attention bestowed upon the carrying out of the process of purification at these works, and more especially at Bow, which would obtain a much lower amount of sulphur in the gas than at present exists; and the committee cannot but think that were the maximum considerably lowered, the result would be a corresponding diminution of the daily proportion of the sulphur in the gas supplied from Bow and Beckton. As regards the other gas-works under the supervision of the Referees which supply the Metropolis, the committee consider that a sulphur maximum of 30 grains is no check at all upon the gas companies, seeing that equal results have been obtained without the adoption of any special means or process for removing the sulphur impurity. Such a maximum, therefore, appears to the committee totally at variance with the spirit and intention of the London Gas Acts, 1868 and 1869, and a failure on the part of the Gas Referees to discharge the duty entrusted to them under those Acts.

At that time Dr. Letheby was not advising the corporation upon this point, because he was the chief gas examiner, which was an independent position under the Board of Trade. The principal argument used by the corporation was that because our maximum had succeeded in giving an average very much lower than the maximum (which, of course, it would be) that was an argument why we should bring it down to that point, or near it. It was because the companies had worked very well under our maximum that we should lower it still more. I have a great many more letters, but, unless the committee wish it, I do not think I need trouble them with them. Many of them contain evidence that we had visited the works, and did not find the nuisance which was asserted. I merely mention this to show that whether we were judging rightly or wrongly, we had given all the attention we possibly could to the subject. We also made ourselves acquainted with what was done elsewhere, in order to form our opinion whether or not this was practicable, and we came to the conclusion that it was.

By the COMMITTEE: We visited Edinburgh, and found that lime was used entirely there. The works were in one of the best parts of the town, between Carlton Hill and Canongate, and I went carefully over them. I spent some days with the manager. I found that lime was used exclusively. I was living in Princes Street during the time when the wind was blowing from the works towards the hotel, and I noticed no nuisance, and there was nothing in the gas which gave me reason to suppose that it would be impossible to purify it by lime. There were no complaints from the hotel-keepers. If there had been a nuisance it would certainly have occurred at that time, because it was the most favourable time for it. The wind was blowing strongly from the gas-works towards the hotel. I noticed that at the time, and I communicated with the authorities. I think the purifiers were opened while I was there. I may say that I also went to Nottingham, and found exactly the state of things that has been given in evidence by Mr. Loam. I could not do better than refer to his evidence. I also went to Leeds. The Leeds Gas-Works are situated in a populous district and lime is used there.

By Mr. CRIPPS: I do not know the amount of sulphur impurity remaining in the gas. I also made inquiries at different times as to other towns. I was engaged myself professionally at Pontefract, a small town truly, but where gas was made for the whole population, and nothing but lime used there. They had never heard of the oxide process.

By the CHAIRMAN: I am not aware that they took any special precautions at Edinburgh. The purifiers were under cover, and the lime was put into railway trucks and sent immediately away. It was not stored. If it had been stored, the manager told me, they would have had some difficulty, but it was sent away immediately.

Cross-examined by Mr. MICHAEL: At Haggerston we discovered a nuisance, but nothing to speak of. At Pimlico there was a nuisance, decidedly. I myself did not direct the engineer at Pimlico to adopt any other measures than he was then adopting. Mr. Harcourt, as he told you, made several suggestions; but I do not think that personally I ever made

any suggestion, because my view was that it was not our duty to do so. We were merely to satisfy ourselves whether the process could reasonably be carried on without a nuisance. I have never been an officer of a gas company, but I have had, as an engineer, a great deal to do with gas-works and gas manufacture, beginning from the year 1838, and continued more or less to the time when I was appointed by the Board of Trade. I told them very freely and candidly exactly what my qualifications were, and I asked them to refer to certain authorities—I mentioned the best known gas authorities in London—as to whether I might be considered a competent person to fill the post. What answers they got I do not know, but the result was that I was appointed in 1870.

By the COMMITTEE: In several cases we found there were no precautions taken at all. At Bromley, for example, the thing was worked just as if the material had been entirely innocuous and inoffensive. I am not quite sure whether or not I signified to the engineer that there was a want of proper care and precaution in carrying on the process. I think that Mr. Harcourt did; he has generally done that.

Mr. O'HARA: With proper care, do you think that the company could reasonably be required to keep their gas as pure as you prescribe?

Witness: We answer that by prescribing the maximum. It is more a question of expense than of care. I do not at present see that increased expense need be incurred, but it is possible that some expense might be.

The COMMITTEE: What Mr. O'Hara means is this. Do you agree that twopence would be saved if there was no restriction at all?

Witness: I have no knowledge about that. It is generally assumed by engineers that the total cost of purifying by lime is about a penny per 1000 cubic feet; and I know when the commissioners settled the price of gas some time ago, they allowed a penny per 1000 feet extra to the companies, on the ground that we had required them to use lime. I may say, upon the question of price, that we have been often assured by the representative of one of the largest companies in London, that the use of lime was not so expensive as was generally supposed, because it left the gas of a higher illuminating power; but I have no knowledge on the subject myself.

Professor *Tyndall*, examined by Mr. ROUND.

I have listened to the evidence of Mr. Harcourt and Dr. Pole, and I entirely agree with my two colleagues as regards this question. I was very much struck by a remark that was let fall by Dr. Pole, that the nuisance was very frequently absent when we were there, for that entirely coincides with my individual experience on some occasions. I have made the remark that the nuisance appeared to me exceedingly small, and the answer of the engineer was: "This is a particularly favourable day. It is not so bad to-day as it is sometimes." I am quite within the mark in saying that that answer was given to me at least twice by different engineers. Again, I went down to Fulham, and went round the works there, and I must say I was exceedingly impressed with the great care bestowed upon this question at the Fulham works. The amount of care shown was infinitely greater than the care expended at the other works. I had the honour of being accompanied on that occasion by a person for whose opinion I have a very great esteem, and who has particularly good olfactory nerves—I walked in company with my own wife round these works. I took particular care to go to leeward, and Mr. M'Minn, the highly intelligent engineer of the works, was there. I said to him: "Why, Mr. M'Minn, we are here to leeward; the wind is blowing from the purifier towards us, and there is no nuisance here." He made the same remark as before, adding that possibly there might have been a nuisance half a mile away; that the nuisance might have got upon the air and have been wafted through the higher atmospheric regions, and might have descended at a distance; but I can truly say, as far as my observation went—and I gave the matter all due care—that I am disposed to give the gas company very great credit indeed for the care bestowed on this question at Fulham, although not at the other stations, I am bound to say. I think there is a great deal to be said for the gas company. It is a process that requires a good deal more trouble than appears, but I cannot entertain a doubt

that if the company took it up with vigour, and with a determination to solve the problem, they are quite able to do it.

Cross-examined by Mr. POPE: I only visited Fulham once; but I have not the slightest recollection that two or three hours after I left there I experienced any effects as if I had inhaled sulphuretted hydrogen or anything of the kind.

Mr. POPE: Assuming that a person's experience on the spot was like your own, that this nuisance was exaggerated, and that you found two hours afterwards nausea and all the symptoms of inhaling sulphuretted hydrogen, how would you account for that?

Witness: If any such results had occurred to me, I should have given strong testimony against the lime purification.

Then I may take it that if that was the result of a visit to Fulham, although you at the time were unconscious of a nuisance, you would be prepared to state to the engineer that that was all "bosh"?—I never used that term, sir. The engineer at Fulham is, as far as I could judge, a perfect gentleman, and I conversed as a gentleman with him. If I could trace symptoms of that kind to the use of lime, I should say, "Away with it; let us not have it," undoubtedly.

But is it possible that you might have diffused through the atmosphere sulphuretted hydrogen, to an extent not appreciable by smell, so as to make it an insufferable nuisance, but afterwards acting so as to produce the symptoms I have mentioned to you?—If you ask me if such a thing is possible, you make the range of things so large that I should be very sorry to say it was impossible, but I think it is in the highest degree improbable.

At all events, your experience was limited to one visit. I should not myself have generalized from one visit; but it is from one experiment that you draw your conclusion that there was no nuisance at Fulham?—I have given you the data upon which I have founded my opinion. I have been at other stations besides Fulham. When I went to Fulham a light wind was blowing. I went to leeward while the purifier was being opened, and my private conclusion at that moment was that, if on all other occasions the selfsame amount of care was devoted to the emptying of these purifiers, that was devoted to the one when I was there, we should have very little complaint on the part of the inhabitants of Chelsea.

Did you at that time adopt any test to ascertain whether there was any sulphuretted hydrogen present?—None, save the test that nature gave me, which is one of the finest possible.

At Fulham the purifiers are in the open air, so that, at all events, the absence of nuisance at Fulham was not due to the purifiers being covered with a shed?—I can only say that the nuisance was certainly absent. I understand from Mr. Harcourt's evidence that care had been taken to draw air down, so as to carry the foul air away, and perhaps to the withdrawal of this foul air the absence of nuisance may have been due.

Cross-examination continued: When I was at Pimlico the lime was bare and naked when shot into the barge, and the stench was wafted from that bare and naked lime to my nose. I believe that was the sole weak point in the arrangement at Pimlico. If the source of nuisance when I was there was perfectly and properly dealt with, then I should say there ought to be no nuisance at Pimlico.

Mr. POPE: I understand both you and Dr. Pole rather referred to Mr. Harcourt for suggestions. Do you think the getting out of this sulphur of any great importance?

Witness: Perhaps I can best answer that question by entirely endorsing what has been said by Mr. Harcourt. Were I offered gas with the sulphur at 3s. 9d., and the same gas without the sulphur at 3s. 11d., I should certainly, without hesitation, pay the 2d. extra for the pure gas. It is very difficult—indeed, it is perfectly impossible—to state the proportion, or express numerically, the amount of danger or damage done by impure gas. But, if you agree with Mr. Harcourt, he is of opinion that there is no great necessity for the removal of this extra amount of sulphur. Is that your opinion or not?—I should be very sorry to attach too great importance to it; still I think it is very desirable to have the sulphur as low as it practically can be kept. At all events, from the evidence I have heard

and read upon the subject, there are possibilities open, and always, I think, on public grounds, it is better to err on the safe side.

Have you given personal attention to the investigation of the gas question at all?—Will you allow me to answer that question by referring to my first appointment as a Gas Referee? I was written to by Mr. Farrer, at the instance of the late President of the Board of Trade, I think Lord Carlingford. I wrote to Mr. Farrer, saying, "I am not professionally a chemist. I am a Professor of Physics in the Royal Institution. I do not undertake to make chemical experiments of the examination of gas. I am acquainted with the process of photometry, and if any physical question should arise, I might be able to cope with such a question." Mr. Farrer wrote in reply that "that is exactly what we want; we have Dr. Pole and Mr. Harcourt, and we want a gentleman of your acquirements to meet these other cases;" and he said, "I am perfectly willing to give you my advice gratis whenever you wish to call upon me." It was almost under pressure that I accepted the office of Gas Referee. I have not made any chemical experiments with regard to gas, but I am perfectly competent to form a sound scientific opinion upon the questions that come before me.

By the COMMITTEE: I have made no experiments regarding the effect of sulphur compounds upon health, or upon the binding of books or the gilding of frames. I have made experiments, but of so restricted a character that I should not state them here as experiments of authority.

MONDAY, MAY 14.

Mr. ROUND said he had done all he considered necessary, and would now do no more than watch the proceedings, and see what course his learned friends took.

The CHAIRMAN said the committee were of opinion that, so far as the existence of the smell went, they were satisfied that there was a disagreeable smell produced from some of those works, and they did not require any more evidence upon that subject. Of course, they expressed no opinion as to the cause of that smell, nor as to the possibility of curing it.

Mr. *Harry James Veitch*, examined by Mr. RICHARDS.

I have resided at 34, Redcliffe Gardens since June, 1876, and carry on business at the Royal Exotic Nursery, in King's Road, Chelsea. I have there a very large conservatory, and a very choice collection of plants. I formerly resided at my place of business in King's Road for 23 years. The acreage of my garden is 5½ acres, and I believe I am one of the largest nurserymen in the world. I have frequently observed a disagreeable smell in King's Road, when the wind comes from the south-east, which I am certain comes from the gas-works. I have seen a slight vapour arising from the purifiers when they were being emptied. I have observed that smell in my glass houses, which are as impervious to the entrance of dust as we can make them, with regard to the cultivation of plants. The smell has been the worst when the atmosphere has been thick and muggy. I do not think it possible for the dust to be carried to the houses from the gas-works. I have never detected any dust in the atmosphere coming from the gas-works. The leaves of our rare plants are so looked after that dust would be immediately detected if it was there. I do not know of illness of any sort in the family of the foreman who resides in the nursery, but the wife of one of our other foremen has on several occasions, when the smell was bad, been quite sick. My own brothers and sisters have suffered from nausea, and from headache also, but they have never been actually sick. I drew up a petition to the Kensington Vestry last year, after I went to Redcliffe Gardens to live, to which I obtained one or two signatures from my friends, and then I left it with my landlord to obtain further signatures. I believe there were about 30 or 40 signatures in all.

Cross-examined by Mr. O'HARA: The smell has been much worse within the last two or three years. My gardens are about half a mile from the gas-works.

Mr. O'Hara: You stated that you saw vapour arising from the purifiers; how did you trace the smell to those purifiers?

Witness: I am generally in my business early in the morning; and when the smell on one or two occasion recently has been very bad, I have passed into the King's Road towards the gas-works, and from the bridge which passes over the railway adjacent to those works you can see the purifiers being emptied, and when the purifiers are uncovered the vapour rises.

Why did you go to live at Redcliffe Gardens, so near the smell, if you disliked it so much?—Because I wanted a better house, and I also wished to be as near my business as I could.

As near the smell as you could?—That I cannot help; but I should like the smell to be removed.

By the Committee: I have other nurseries besides the one at Chelsea, and in driving past to them I have detected the smell. I am told it commences as early as five o'clock in the morning, according to the state of the atmosphere. Sometimes our greenhouses have been permeated almost all the day. When the atmosphere is very heavy and foggy the smell will not go off; but if the air is lighter, it passes off perhaps by nine or ten o'clock in the morning. When the wind comes from the south-east, we have had it for four, five, or six mornings consecutively. I noticed it last Wednesday, but we have not had a great deal of south-east wind lately.

We had a great deal about a fortnight ago, was it bad then?—Not so bad as I have noticed it sometimes.

Do you find the health of your plants at all affected?—It is difficult to prove that they would be affected by it. We have noticed that when the gas fumes have been prevailing in the houses, and have continued morning after morning, the plants have not lasted so long as they do when the wind comes from another direction, but to say that it is caused by the fumes of gas is more than I can do.

Do you perceive anything on the leaves?—No; we have noticed the leaves of the plants and cannot. I have tried to detect anything on the water, but I have not been able at any time to do so.

Dr. *Andrew White Barclay*, examined by Mr. Michael.

I am a physician, practising in Bruton Street, Regent Street, and am Medical Officer of Health for the Parish of Chelsea. There have been numerous complaints made to the Vestry of Chelsea with respect to the nuisance arising from the gas-works. The present series of complaints commenced about 1878, and have continued up to the present time. Towards the end of 1878 I visited the works for the purpose of ascertaining what operations were being performed which might lead to the nuisance, and I found they had been obliged to resume the use of lime. At that time they were largely increasing their plant (in order to meet fresh restrictions which they gave me to understand had been placed upon them) by which they hoped that the nuisance might be prevented. The vestry appealed to the Gas Referees, who reported that they had no power to control the manufacture of gas, and then steps were taken to apply for an injunction.

Mr. Michael: In the end of 1876 and the beginning of 1877 did you continue to visit the gas-works?

Witness: Yes; and agreed with the solicitors, Messrs. Lee and Pemberton, that continuous observations should be made by the residents in the parish, as to whether there was any abatement of the nuisance subsequently to the date of the Gas Referees report. I visited the works on the 14th of January this year, in company with the resident engineer, and the process of purification was explained to me, so far as it was modified up to that time. I have seen the purifiers emptied, but not very recently. I saw one of the Powell purifiers emptied in 1876, I think, and at that time sulphur compounds were given out into the air, of a noxious character, and such as, in my opinion, would be injurious to health.

Mr. Michael: As far as you could judge, do you think that any want of care was exhibited by the persons who had charge of the purifiers?

Witness: I do not think any want of care was exhibited. I have always

appealed to the gas engineer whether other means might not be adopted; but, not being a skilled chemist myself, I have not been able to suggest any such means. Cards have been prepared, to be distributed among a certain number of residents, in order to have an accurate report of the condition of the nuisance up to the present time; but the returns are not yet completed. That is with the intention of applying to the Court of Chancery for an injunction against the works. It must depend upon the weather how long those reports are to be continued. We must have westerly winds before we can get accurate reports. There have been several letters from the inhabitants complaining of the nuisance.

Cross-examined by Mr. O'HARA: I drew up a large sheet of paper, with a column for each day, and wanted certain observations to be filled up in a tabular form, for the purpose of ascertaining whether there was any amelioration of the nuisance or not.

Mr. O'HARA: You say that in 1875, when you were at the works, you noticed smells, and you detected sulphur compounds; that is, that you think so—you cannot say?

Witness: One can generally detect them by one's nose.

You detected these sulphur compounds. Did you consider as to whether or not the lime purification could be done without causing this smell? Did you give your mind to that at all?—I have thought it over, but I cannot say that I have come to any satisfactory conclusion in my own mind.

Cross-examination continued: I heard of the great inquiry before Mr. Forster's committee about the supply of gas to the Metropolis, but I was not summoned on that occasion.

By the COMMITTEE: I think the arrangements at the Fulham Gas-Works are rather more complete than they were, and that there is substantially an abatement of the nuisance, but unless the purifiers can be deodorized at the time of opening, I see no means by which the nuisance can be entirely abated. I cannot say that the process of passing a down draught of air has obviated it to any extent, for the reason that the gas company have been in the habit of doing so almost from the first time I visited the gas-works after the lime process was introduced. They adopted it before it was suggested to them by the Gas Referees.

Mr. *Richard Thomas Daniel*, examined by Mr. RICHARDS.

I am a Fellow of the Royal College of Surgeons in Ireland, and a Bachelor of Arts and Medicine, residing at 20, Cathcart Road, South Kensington. I was selected by the men to act as surgeon to the Imperial Gaslight and Coke Company at Fulham, in January, 1865. During the last two years I have had several complaints from the men engaged in removing the purifying material. I found them suffering from sickness, nausea, and loss of appetite. In addition to the complaints of the men, I have had frequent complaints from residents in the neighbourhood. I presented a petition last year to the Kensington Vestry upon the subject, of which vestry I am a member. The smell was at first attributed to other causes, but I satisfied myself that it proceeded from the emanations of gas. When the petition was introduced to the vestry, I moved a resolution that Dr. Dudfield should be requested to go down and report upon this alleged nuisance. He did so, and his report was sent to the Metropolitan Board of Works, to the Gas Referees, and, in fact, to all the public bodies who could bring any influence to bear upon it.

Mr. O'HARA objected to the report being read unless Dr. Dudfield was to be called.

The CHAIRMAN said he could not allow the report to be read.

Examination continued: I have resided in the neighbourhood for 15 or 16 years, and, in my opinion, the nuisance from the gas-works has very largely increased within the last two or two and a half years. When the purification was entirely by peroxide of iron, the nuisance was nothing at all compared to this. I was not aware that Dr. Letheby has stated that 1 per cent. of sulphuretted hydrogen in the air would be destructive of human life, but I should say that would be the case. In consequence of Professor Tyndall's remarks the other day, I determined to go this morning to the Fulham works, as I knew it was likely the purifiers might be

opened. I left my house at six o'clock, and went straight down in the direction of the gas-works, and I did not observe the slightest smell. I went into the works, and asked the foreman when a purifier would be opened; he said in a very few minutes, as the men were just coming in to open it. I witnessed the whole process, and the stench was most intolerable. The wind was not in the direction of our neighbourhood, and the weather was very foggy, warm, and misty. I felt myself quite nauseated by the smell. I saw all the process carried out, and all the suggestions which I heard Mr. Harcourt talking of the other day; I also made inquiries, and satisfied myself that there was a down draught of air being carried through the lime. The barges and all things else were covered up, and in no way possible could this smell escape after the lime left the purifier. No suggestion occurred to my mind that would make the system more perfect.

Cross-examined by Mr. O'HARA: I went to the works because Professor Tyndall stated distinctly that he was present with his wife, and that there was no smell from the purifier, and I knew there must be some mistake, so I went to satisfy myself. I never passed a purifier from which there was not a smell, and I have passed them hundreds of times. I smelt some gas tar this morning, but it is a very different smell from that which the purifiers give off.

The COMMITTEE: Do these men complain of their eyes or hands being injured by the lime at all?

Witness: Not their eyes. Frequently, if their hands get a little moist in shovelling out the lime they get very severe burns, which are worse than burns inflicted by plain lime; they get poisoned wounds, but I have never heard them complain of the dust.

With regard to Dr. Letheby, you said he calculated that if there was 1 per cent. of sulphuretted hydrogen in the air it would be injurious to health. Does that apply to gas burnt in a close room or in the open air? How do you apply this dictum of Dr. Letheby's upon the subject?—I apply it in this way—that sulphuretted hydrogen, to persons inhaling it with other compounds, is injurious to health.

In the open air?—Yes; it fills the rooms in our neighbourhood completely, although the windows are closed. My own servants complain of it, and it has been attributed to our sewers; but I have had everything done that can be done to our drainage, and I believe it is perfect.

Mr. *Frederick Alexander M'Minn*, examined by Mr. POPE.

I have been engaged at the Fulham station for 18 years, and have been chief engineer there for two years. That station originally belonged to the Imperial Gas Company. In the summer of 1873 our directors, who were then the Imperial, became aware that the Gas Referees would very shortly place them under the particular restrictions as regards purity from sulphur compounds, which they had previously insisted upon with regard to the Chartered Company, and it was therefore necessary to commence, in anticipation of their demands, some preparation, in order to enable us to purify our gas. We made up our minds that the requisite amount of purity could be obtained only by the use of lime. It was in June, 1873, after the Referees were appointed, that the purifiers were first charged with lime at the Fulham station. As soon as we commenced using the lime process, it was found that our purifying capacity was quite inadequate for the purposes required by the Referees. It necessarily involved a frequent substitution of fresh lime, in order to purify the quantity of gas required. We did succeed in keeping down the quantity of sulphur pretty successfully from that time, but it was with very great difficulty, on account of our limited purifying area. we had to change the purifiers very rapidly. A great nuisance was certainly created. In the winter of 1873-74 a number of lights were transferred to another station, so that we might enlarge our purifiers at Fulham. On the 9th of February, 1874, I received a letter from Mr. Chubb, the secretary of the Imperial Company, enclosing a complaint from the Metropolitan Board of Works with reference to the nuisance which was being created. By the winter of 1874 it was found that it had not been possible to get all our new purifiers ready in time for the winter,

and we applied to the Referees for some relief from the maximum of sulphur which they required, but they declined to make any alteration in their order. Notwithstanding that our apparatus was not perfectly completed we succeeded in purifying the gas substantially as the Referees required; but we had great difficulty in doing it. On several occasions we were above the mark, but the matter was leniently considered, by reason of our works not being actually completed. On the 28th of January, 1875, Dr. Barclay visited our works with reference to complaints of the nuisance that were being made. He especially referred to a nuisance on the 20th of the previous December, and I explained to him that it was due to our being obliged to change the purifiers rather sooner than we ought to have done, because if we had allowed the matter to go on longer, we should have had our sulphur above the maximum. On the 24th of August, 1875, Dr. Barclay came to the works and made further complaints of the nuisance which the district and his neighbourhood were feeling. Up to that time I had been giving every possible attention, both to secure a proper purification of the gas, and to minimize the nuisance as much as possible. Up to the end of 1875 Dr. Barclay, from time to time, visited the works, and I explained to him the system of working the purifiers by rotation, which I hoped would do away with the nuisance. I may illustrate what I mean by this [producing six cards]. We have a set of six purifiers; they are placed in this way, and we thought that by continuing the flow of gas through the whole of the series, we should be enabled to convert the lime in the first purifier into carbonate of lime, so as to prevent the nuisance caused by the sulphide of lime; but we found that by adopting that process, it drew the whole of the sulphur out in this first purifier in such vast quantities, that it was impossible to prevent it going into the gas, and therefore we had to abandon that process. In July, 1876, I received still further complaints from Dr. Barclay of the nuisance arising from the Fulham works. He came to the works, and I was extremely vexed to see him, because my impression was that I had been successful in reducing the nuisance to such an extent that it would not be noticeable. I told him exactly what I had done, and what difficulties I found—that, in truth, I could not, by the rotatory system I have mentioned, purify the gas, and at the same time avoid the nuisance. From that date, therefore, the system of working the purifiers in rotation was abandoned.

Mr. POPE: Let me ask you this, because a great deal seems to turn upon it. Did you do everything which your knowledge, care, experience, and supervision could do, to carry out this in a successful way, in order to accomplish the double result?

Witness: I did.

Honestly, with the view to do it, if possible?—Yes.

I think you say that you thought yourself you had succeeded in minimizing the nuisance?—I did.

Examination continued: In September I received instructions from our directors, in common with the other engineers of the company, to try the ventilation of the purifiers that has been mentioned by Mr. Harcourt. I have a copy of the directors order:—"That the foul lime at all stations be completely ventilated prior to removal."

Mr. POPE: How soon after that order did you proceed to apply to your purifying chambers this ventilating process?

Witness: I did not apply it further than on one occasion only. I found then that the temperature of the lime was increased to such a very great degree, and the length of time occupied in ventilating the whole of the lime would have been so great, that, in the first place, I could not open the purifier long enough, and, in the second place, I seriously apprehended damage to the vessel itself. I should also add that the nuisance caused by heating the lime was so much greater than that ordinarily caused, that I abandoned it simply on that account. After carrying the experiment on for, I think, five days, I found that I should want the purifier again for use, and I had to stop the process; and in order to get the purifier empty I had, as it were, to bribe the men to go into it on account of the terrible state the lime was in.

By the COMMITTEE: The heated condition of the lime was caused by the action of the oxygen of the air in passing down through it.

Examination resumed: I have since modified that process, and now simply carry it to the extent of removing the gas itself which remains in the purifier after it is shut off; and also, as I have always done from the introduction of the lime process, I draw the air down while the operation of emptying the purifier is going on. On the 16th of October I received the following letter from Mr. Cox, of the Boltons, South Kensington, complaining of the nuisance:—

Sir,—I think it is a sin and a shame that the inhabitants of this neighbourhood are made to suffer from the filthy exhalations emitted from your works. Daily this beastly nuisance continues, which is seriously affecting the health of one of the inmates of my house. I shall be glad to have some explanation from you on the matter; and, failing this, measures will be taken to put a stop to this abominable state of things. Your immediate attention will therefore oblige. Yours faithfully,

WILLIAM H. Cox.

At the same time the Kensington Vestry appeared to be stimulated by the action of the Shoreditch Vestry, and on the 4th of November Dr. Dudfield, the Medical Officer of Health for Kensington, visited the works and complained of the nuisance. I have here a copy of Dr. Dudfield's report upon this visit.

Sir E. BECKETT objected to the report being read, and

Mr. POPE said he did not think it was very material.

Examination resumed: On the 17th of November I received an intimation from Mr. Harcourt that, in consequence of the complaints of the Chelsea Vestry, he proposed to visit the works and inspect the process of purifying, which he did on the 22nd, in company with Dr. Pole. I showed Mr. Harcourt the whole of the arrangements that were going on—the trucks, the means of covering the lime, and the hood for shooting the trucks under; and I also showed them the means for covering the barge over to prevent the escape of dust, as far as possible. I delayed opening the purifier till the arrival of Mr. Harcourt and Dr. Pole, when the lid was raised, and the operation commenced. I mentioned that Dr. Barclay had suggested the application of chlorine gas to deodorize the lime, and I explained to the Referees how he suggested it; but they agreed with me that it was quite impracticable, and could not be carried out. Mr. Harcourt then observed that, while the men were removing the lime, there was some dust thrown up. The lime was dry—it very often is dry, but at other times it is quite moist in itself—and he suggested the application of water to the lime, as he thought that nuisance was caused by the dust escaping. I undertook to do that. Mr. Harcourt also proposed that we should cover the lime over with tarpaulins, or cloths of some sort, in order to prevent the escape of effluvium, and that I undertook to prepare for on his next visit. Before leaving, Mr. Harcourt thought over the idea that had been thrown out, about the application of chlorine gas, and then they proposed that we should try an experiment with chloride of lime; that we should take some wooden trays, and place some chloride of lime upon them. Supposing a purifier is being opened and the wind was blowing in a certain direction, the chloride of lime should be placed here [pointing on a model] and treated with an acid, so that the chlorine gas should be thrown off; and he thought that if those two gases came in contact with the air the one would deodorize the other. I undertook to do that on the next visit. I remember Dr. Pole suggesting that that would "catch it on the wing," but it did not seem to me altogether practicable to do it, because chlorine gas is a gas of very heavy gravity, and would fall quickly, whereas the other gas ascends; however, I undertook to carry it out.

Mr. POPE: Excepting the wetting of the lime and covering the surface during the discharge of the purifiers, was the whole of the rest of the process described by Mr. Harcourt in operation during the time that those complaints were being made against the stench from the works?

Witness: It was; everything was in use.

That being so, if there be any nuisance at Fulham, is it in any way due to negligence, or carelessness, or indifference upon your part, as to its existence or cure?—No, it is not. I have taken the greatest possible care that any man can to prevent that nuisance, and I am constantly supervising it.

I may ask you this question generally: Have you been able to get rid of

the nuisance which is occasioned by this system of lime purification?—No.

In your opinion, is it possible to carry on a system of lime purification involving the reduction of the sulphur compounds to the extent prescribed by the Referees without causing a nuisance which may be offensive to the neighbourhood?—No.

You have exhibited no disinclination, whether natural or otherwise, to cope with this problem of gas purification?—None whatever. I have met everything that Mr. Harcourt has suggested to me most cheerfully, and endeavoured in every way to improve upon what we did before.

Mr. Harcourt seems to think that at Fulham, to do you credit, everything is done which can be done. Let me ask you, in your judgment, though everything is done which can be done, have you solved the problem at Fulham?—I have not. I suffer from it myself, and I would endeavour, if I possibly could, to remove the inconvenience for myself, if not for anybody else; but I have not been successful in doing it, although we have spent considerable sums of money in endeavouring to solve this difficulty.

In pushing the process of deodorizing the sulphide of lime to the full extent, is there any special danger which has been found in the manipulation of that process?—Yes, unquestionably a danger. The action of oxide of iron upon sulphuretted hydrogen is to form a sulphide of iron, and when the oxygen again meets with it, it re-forms the oxide of iron and precipitates the sulphur. That is in the form of uncombined sulphur, and the amount of heat evolved during that process is sufficient to ignite the sulphur. Then you have the purifier full of gas, and when you use the ventilating process you have to drive it down and pass it through the oxide, and that in itself is somewhat dangerous, by reason of its being an explosive mixture when mixed with common air. If you go on, and draw down the sulphuretted hydrogen, that, when mixed with common air, is also an explosive gas. Again, in carrying on this process, every time you do it, the heat here [pointing to the model] is sufficient to ignite the sulphur. We saw that difficulty long before the lime process was introduced, but more especially since then, because I constructed vessels, with closed covers, with a pipe to carry off the vapours other than sulphuretted hydrogen, and I put on them two large valves, in anticipation of such an accident happening as an explosion. We subsequently found, in carrying that process out at the Bromley station, that an explosion did happen there; and I then ceased using the closed vessel, and constructed this open vessel. We then introduced a steam-pipe into the oxide, the object being to moisten it, so as to endeavour to prevent the ignition of the sulphur. There is a great deal of heat given off from the purifier during the ventilation of the lime to the fullest extent, and the steam dries the oxide to such an extent at the bottom layer that it is still liable to ignite. It becomes hot and dry, and then chemical action goes on, and the sulphur is heated, and sufficient heat is still created to cause an explosion, although you introduce the steam by way of preventing it.

As I understand, the ventilation that Mr. Harcourt spoke of in terms of praise cannot be safely carried beyond the point at which you carry it at Fulham, because of its tendency to heat the lime in the purifier itself, which, of course, renders the lime even more offensive than it is to begin with?—Yes, unless you carry it to the full extent, and completely deodorize it.

If you carry it to the full extent, then you run this risk of carrying over other sulphur compounds, and creating another smell, or an explosion, from the causes that you have mentioned, either the leakage or the heating?—Yes.

Have you therefore carried out this process of ventilation to the utmost extent that you consider it safe in your experience to follow?—Yes; seeing that I have a great number of men in my charge, I consider that I do carry that process as far as it dare be carried for the safety of the men.

Notwithstanding all that, there does exist the nuisance which you have mentioned at Fulham, and which is, to your mind, inevitable?—Yes. There is an incident I may mention. It appears to me, from all the Referees have said, that they have in their minds an idea that I do not

carry out this process carefully. They always point to that, that if these processes are carried out carefully, there is no nuisance. I can only give you my honour as a gentleman that I do carry out these processes to the fullest extent; that is the most forcible way in which I can tell you. On one occasion, Mr. Harcourt came down to the works without a previous appointment, at a time when we were fully engaged in emptying a purifier. He came into the works, and went to the purifier that was being emptied. It was reported to me immediately that he came, and I was rather nettled, because I thought it implied a want of confidence that I was not carrying out these processes exactly as they ought to have been done, and I did not go to join him. I thought he might investigate as far as ever he chose. In about half an hour my foreman came to me and said that Mr. Harcourt had asked him to take a piece of lighted yarn, so that it would smoulder, and smoke, and hold it over where the lime had been removed, in order to see if the draught from the exhauster was really drawing down the air, but my foreman declined to do that. He said it was so dangerous an experiment that he dare not do so without my authority, and he came to me to ask whether he was to do it. I said that I was greatly obliged to him for not doing such an extremely dangerous thing, because there was a decided danger of a serious explosion, and it might have cut my works in half. I look upon that as an instance of the want of practical knowledge those gentlemen have in the internal economy of gas-works. A practical gas engineer would certainly never have dreamt of proposing such a trial as that. I do not desire to throw any disrespect on Mr. Harcourt in any way, or upon any of the Referees. They are no doubt able men; but I say that the practical knowledge which is so essential was absent.

Cross-examined by Sir E. BECKETT: We found it very inconvenient being under the 20-grain test in the summer of 1874, because our purifying apparatus was not large enough to enable us to comply with the Referees requirements.

Sir E. BECKETT: You received a letter upon the subject, did you not, from the Referees, on Nov. 14, 1874?

Witness: I do not know of any.

Sir E. BECKETT said it was not very long, so he would read it:—

17, *Buckingham Street, Adelphi, Nov.* 14, 1874.

We have to thank you for your letter of the 2nd of November, giving us the information asked in our letter to you of the 12th of October, in reference to the increase your company are making in their purifying apparatus. We were desirous to obtain complete information on the facts, before reconsidering the maximum of sulphur impurity we have prescribed, and we are happy to express our satisfaction with the measures your company are taking to increase the purity of the gas supplied by them, and our sense of the difficulties which have delayed the execution of those measures.

Having now the facts correctly before us, we have carefully considered your request; and we may say at once that if we were convinced that the retention of the maximum at the present amount would press so hardly on the company as to be likely to subject them to fine through the fact of the accidental non-completion of the new apparatus, we should be disposed to make a relaxation in their favour. But on carefully considering the data before us we cannot come to that conclusion. In the first place, looking at the sulphur returns of last winter, we find that, although the maximum then in operation was 30 grains, the actual amount did not often exceed 25 grains. The principal exception occurred at the Haggerston works in December, and at Fulham during the other half of the same month.

In the following month, owing, no doubt, to increased experience in the management of lime, although the make of gas had scarcely at all diminished, a maximum of 28 grains was never exceeded at Haggerston, and on three occasions only at Fulham. At the St. Pancras works the same maximum was exceeded twice only in each of the four winter months. Since that time two advantages have accrued to the company, which should enable them to supply gas of a somewhat higher degree of purity than last winter—first, the opening of the spacious works at Bromley, which enables them to transfer a portion of their make from works, the demand on which has outgrown the means of purification, to a place where every facility should exist for the reduction of sulphur to the lowest point; and, secondly, the experience gained not only from the experiments specially instituted by the company on the subject (as named in your letter), but from a year's working of a method of purification, which, even where imperfectly applied, reduces the amount of sulphur considerably below 25 grains. A comparison of the returns of the present year with those of the corresponding period of last year shows very much improved results, which (as there has been no increase of purifying apparatus brought into use at the urban stations) we can only attribute to increased knowledge, care, and skill in the mode of purification.

In the month of October, 1874, the maximum amount of sulphur returned was—

	Grains.
At Fulham	17·6
At St. Pancras	19·3
At Haggerston	18·2
At Bromley	15·4

(excepting two days, on which they were quite anomalous, and evidently accidental). In November the maxima have been—

At Fulham	16·1
At St. Pancras	13·1
At Haggerston	17·1
At Bromley	10·3

The averages have been as follows:—

	Oct., 1874.	Nov., 1874.
Fulham	15·6	14·8
St. Pancras	15·4	12·0
Haggerston	15·2	15·6
Bromley	10·4	7·3
General average	14·1	12·4
The average for the corresponding months of last year were	18·2	20·5

Hence it is clear that your managers are employing their existing purifiers much more successfully than at the corresponding periods of last year, and although the make is approaching its maximum they are keeping a long way below the prescribed maximum of sulphur. At Bromley, judging by the very low sulphur returns, there can be no reasonable doubt of the sufficiency of the purifying capacity; and at St. Pancras four out of six new purifiers are so far advanced that they may certainly be used before the depth of the winter. These two works yield nearly half the supply.

From these data we cannot doubt the power of your engineers, by skill and care, to keep during the winter within the present maximum under ordinary circumstances. It must be borne in mind that if it should be exceeded, owing to extraordinary contingencies, you have your power of appeal, and we have no doubt that in such a case the chief gas examiner would take into consideration any *bonâ fide* plea on your part founded on temporary difficulties arising out of the non-completion of the new apparatus.

You must, we are sure, be aware that the raising of the maximum would be viewed with great displeasure by the public, and it is consequently a step we could not resolve on, except under more urgent necessity on the part of the companies than we at present see. The public may reasonably expect a lowering of the amount of sulphur, now that the practicability of keeping it down has been established; and we hope that next year we shall be able to fix a lower maximum than heretofore.

We take this opportunity of expressing our satisfaction at finding that purification by lime has been carried on at Fulham during the summer without a repetition of the former complaint of nuisance to the neighbourhood. We were confident, at the time you brought this matter before us, that such a result might be achieved by care and skill on the part of your managers, and we are pleased to find that our anticipations have been realized.

That letter was signed by the Referees. (To witness:) Do you wish to make any remark upon that?

Witness: With regard to the question of sulphur, that is not the point at all. We have complied with the Gas Referees instructions entirely upon that.

Sir E. BECKETT: What do you say to the last paragraph?

Witness: I do not understand it. I never heard of the letter before.

Then Mr. Chubb did not think it worth while to communicate with you about it?—I do not know; I cannot tell you what was in Mr. Chubb's mind.

Then we must ask Mr. Chubb. Did you take any part in the proceedings in 1875 before Mr. Forster's committee?—I had nothing whatever to do with that matter at all. I was devoting my attention to suppressing the nuisance, although unsuccessfully.

If these Referees continue—or better Referees, if you would like to have some better—you would go on trying experiments to get rid of the nuisance?—I consider, so far as the lime process is concerned, that I have done everything that can be done, and the Referees agree with me.

When you say everything has been done that can be done, do you mean, to repeat Mr. Forster's question in 1875, that science is never going any further?—No.

If the Referees continue requiring you to keep down the sulphur, will not you go on continuing to try fresh experiments in order to do so?—Not

after this lime process. My mind is made up on that point; I have brought it to the practical limit. I cannot improve on the experience that I have had, and I am not aware of any other process.

Everything must have a beginning. Will you take upon yourself to say you are satisfied that science can never find anything?—They may discover something a hundred years hence.

Supposing you are under two fires, the Referees on the one hand and the penalties on the other, do you not think it would be worth while going on, and possibly paying scientific men to try and invent some process?—I hardly think you mean that it would pay anybody to try and invent a process.

Such things have been done in the world?—It seems such an extraordinary question, that I find some difficulty in answering it.

It is an unpleasant question, no doubt?—It is a myth. I cannot define in my own mind how I am to set about giving a practical answer.

Mr. Pope: Then you think it is fair to say that we are to be put under penalties until somebody can invent something to get rid of the lime process.

The Committee: Mr. Harcourt told us that these limits depended entirely upon the lime process.

Sir E. Beckett: I want to know whether this gentleman is confident that nothing more can be done by way of improving the lime process to get rid of the nuisance?

The Committee: The question to Mr. Harcourt was to that point, and he said if purification proceeded upon any other process the limit would have to be temporarily abandoned.

Sir E. Beckett: Then he would abandon it. (To witness:) If, on the other hand, this Bill is passed, relieving you from the Referees, what motive will you have to try and purify the gas and get rid of the sulphur?

Witness: If we possibly could discover a process, we should. I have lately been trying experiments myself with that view—we are constantly doing so; and if we were to eventually discover such a process, we should, of course, adopt it.

Why "of course," without any Referees?—Simply we should, as we always have done, be doing our best to carry out the intention of reducing the amount of sulphur in the gas; but I have no grounds for saying there will be a success. The experiments I tried are entirely abandoned, and I do not at present know any other direction in which to make them.

Supposing the Referees are removed, as this Bill tries to do, what motive will you have for taking any trouble to find the means for removing the sulphur?—At the present moment I do not see what motive there is other than the endeavour to reduce the amount of sulphur in the gas supplied to the public.

Do you think there is any harm in sulphur as burnt in a room?—To what amount do you mean?

What amount of sulphur would you like—say 40 grains?—I do not think there is any practical difference between 20 and 40 grains.

You would not think it worth while to try and reduce the sulphur below 40 grains if you were free from penalties?—I say practically there is no difference between the effect of 20 and 40 grains.

That being your opinion, would you take any trouble to reduce the sulphur below 40 grains if you were free from penalties?—If we had a process by which we could do it I would, but it is a question I cannot answer, because there is no process but the lime.

Mr. Pope: We take it for granted that if there were no penalties, practically 40 grains would be the maximum.

The Committee: Is there any amount of these sulphur compounds which is ever produced by the combustion of gas which you think would be injurious, because you speak of the difference between 20 and 40 as not being worth considering?

Witness: Not between 20 and 40; but if it went as far as 60 or 80 grains, or anything like that, I should be inclined to think it was decidedly advisable to remove it, because there would be a greater amount of sulphurous acid formed in the same amount of air in the room, the effect of which would be simply a question of disagreeableness in the room. So

far as the injury to health goes, I think, even in that case, it would not be so in an ordinary ventilated room.

Is there much more difference between the injurious effect produced by 40 grains as compared with 60, than there is as between 40 grains as compared with 20?—It would increase in the same ratio as between 20 and 40 and 40 and 60.

You have thought 40 grains about the happy mean at which you begin to allow it to be injurious?—I think 33 grains was the average quantity of sulphur existing in the gas under the oxide process. I have looked at it in this light, that sulphurous acid is a disinfectant, in point of fact; and it struck me whether or not it is not an advantage, to some extent, to have sulphurous acid. It may seem to be a laughable thing, but sulphurous acid is, nevertheless, a disinfectant.

Would you be quite satisfied to have a limit of 33 grains?—No; because it is a process that we cannot exactly control. It never reaches more than 40 grains, but it will range between 28 and 30 and 33 grains when the purification is carried on by oxide of iron.

In July, 1876, you had the impression that you had succeeded in doing away at that time with the nuisance; what did you form that impression from?—Through the means I adopted there, I thought I had reduced it to such a low degree that it would not be observable; or, if so, not sufficiently to draw forth complaints.

Is it observable in the yard at the present time, when there are complaints in the neighbourhood?—Yes; it is more noticeable on a damp, dull, wet morning; such a morning as this.

If it were noticed outside, I suppose there is no doubt you would notice it inside the works still more?—That would depend upon the condition of the atmosphere. If it was a bright, light, clear day, with a westerly wind, it would rise and go away, and be noticeable more at a distance than on the works, perhaps.

In July, 1876, you did not feel it inside the yard?—Oh, yes, I did, unquestionably.

Then why did you tell us that you thought you had succeeded in doing away with it?—Because I thought it would not reach beyond the works.

Mr. Vernon Harcourt was with you on one of those damp days, and you went about the yard with him; did you call his attention to any smell then?—I think it was on the 22nd when Mr. Vernon Harcourt came. He said to me when he came that he noticed a strong smell, and I took him to a purifier that was being changed; it was a cold, wet, damp morning, and he saw a great deal of vapour rising from it. I pointed out to him some vapour rising from the interstices, which escaped, and he allowed there was a strong smell from that. Then I took Mr. Harcourt round the works, and showed him where the exhauster was at work; and when leaving the works he asked me if there had been any complaints lately, and I said that I had had some, but I pointed out to him that at that time the wind was setting in the direction of the parish of Fulham, and not of the parish of Kensington, and I explained to him that although I had had some complaints there had not been many, and it was due, in my opinion, to the fact that the company's works were situated in that parish, and all the rates, and men's wages, and so on, went into that parish, and they were rather more lenient to us than in the other parish where they had nothing but the nuisance. The remark Mr. Harcourt made was that he wished the wind would always blow in that direction.

Have you made any suggestion to the referees that, instead of fixing a limit of 20 grains and 25 grains, they should give you an average of 33 grains?—No; we have not put it in that way; we have proposed that there should be no limit fixed.

But supposing you could not get that?—We were willing to take 40 grains; but we could not accept 33 grains as the maximum.

Supposing you had more room in your yard, and were, therefore, to have a greater number of lime purifiers, would not that reduce the nuisance very much?—No, I think not; because you have to take out a certain impurity—the bisulphide of carbon; and in order to do that you must have sulphuretted hydrogen and sulphide of lime. If you do not take it out it goes into the gas. Therefore you must remove the sulphide

of lime, drawing with it the bisulphide of carbon, and if that has to be reduced to a certain point, no matter how, you must take it out.

Is it not the case that the oftener you change this lime, the oftener you open the purifiers, and the more rapidly you work, the worse is the smell in the neighbourhood?—If the capacity of the purifiers is not sufficient to reduce properly the sulphur compounds, they must be changed oftener. We have always done so in the summer to the fullest extent, and we are now increasing our purifying plant very largely to enable us to do it during the other months. But you still have to take out the same quantity of bisulphide of carbon, and you must have the sulphide of lime to do that; and if your purifiers are larger, the only difference is that you work them somewhat longer. You are able better to combine the sulphur compounds that have to be removed—that is, the velocity of the gas is less, and it is longer in contact—but, in point of fact, the more you purify the gas absolutely the more nuisance you must create, because you bring more impurity out.

What we want to get from you is this: Supposing you had more space, and a greater number of purifiers, would not that lessen the nuisance, both by the infrequency of opening the purifiers, and also because you would not have to force the gas through so rapidly?—It would lessen the frequency with which we should have to change the purifiers.

You also say if you have to force the gas very fast through the purifiers the effect is worse, so that in those two respects you gain an advantage?—We have an advantage. That is the reason why we have spent so much money in extending our purifying plant, and are proposing further extension.

That would, to some extent, reduce the smell?—In the very depth of winter it would reduce the frequency of changing the purifiers, but at the same time the bulk of lime is larger, and the operation of changing a purifier extends over a longer period; therefore, in point of fact, you have to perform precisely the same work, but in a slightly different way.

In cross-examination by Mr. ROUND, witness expressed his opinion that the foreman at the works had acted correctly in declining to hold a piece of lighted yarn over the purifiers, as requested by Mr. Harcourt, on account of the possibility of an explosion. He also stated that the foreman, although he had no scientific knowledge whatever, was in that particular case the better man of the two, because he had the practical knowledge. The danger of explosion would be from the valves, of which the foreman was thoroughly aware.

Mr. ROUND: This ventilating of the purifier had been going on for some time, had it not? The air had been drawn down through it for all that time, and Mr. Vernon Harcourt knew perfectly well that it was not inflammable, though you set against that the opinion of your foreman, who thought it was?

Witness: I undertake to say that it is most probable that there would be slight leakages from the valves at the bottom of the purifier, which were covered over by the layers of lime, and were not noticeable; and with this down draught, if a spark had been carried down, the gas would have gone below the layer of lime and have caused an explosion.

The operation of drawing down the air had been going on in the open air for hours; it was not covered?—It is open to the air, but the draught is drawing inwards.

Supposing it had resulted in an explosion, Mr. Harcourt would have been the first person to have been blown up?—Yes, and the men occupied in clearing out the purifier. Mr. Harcourt did not know of those two valves, but my foreman did, and he would not allow the trial to be made.

Sir E. BECKETT: Then you would have had a new Referee?

Witness: I should have preferred to have a practical gentleman to see my works.

Mr. ROUND: You give this decided opinion that an explosion would be the consequence?

Witness: Might have been the consequence, because there would be sulphuretted hydrogen as well escaping.

Mr. RICHARDS: Will you ask the witness whether a bit of fluff would not have shown the down draught just as well.

The CHAIRMAN: That is not the question.

Mr. ROUND: You would have the best possible means of seeing, by the smoke, whether there was a down draught or not.

Witness: Supposing an explosion had happened, and had interfered with one of those purifiers, and put it out of use, my works would have been cut in half. It was in mid-winter, too, and that would have been a very grave and serious matter.

One of the two cases may then be apprehended. Possibly an explosion from the presence of a small portion of sulphuretted hydrogen?—Not altogether.

You have alluded to leakage as one cause, but the other was sulphuretted hydrogen coming in contact with the air, and becoming explosive?—Sulphuretted hydrogen is an inflammable gas.

What proportion of sulphuretted hydrogen must there be escaping as compared with the air?—I cannot tell you what proportion. There must be an explosive proportion.

Now we know the extent of your chemical knowledge. I only wanted to know, before you gave your opinion, whether you were acquainted with the A B C of chemistry?—You have no means of ascertaining how much sulphuretted hydrogen is being given off.

We can judge of that theoretically. What must be the proportion of the one to the other before it explodes?—It is impossible to discover that.

Without reference to these particular circumstances, what proportion of sulphuretted hydrogen must be mixed with the air to cause it to explode?—I forget at the present moment, but that it does explode is quite certain; and in addition to that there was the escape of gas from the valves. I particularly mention that more than the sulphuretted hydrogen.

Mr. ROUND said there was a letter he wished to lay before the committee which Mr. Vernon Harcourt had accidentally taken away on the previous Friday. It was from Mr. Evans, dated the 28th of October, and he was merely going to read a passage, and ask the witness whether he agreed with it. Mr. Evans wrote to Mr. Vernon Harcourt as follows:—

My dear Sir,—In reply to your letter of the 26th on the subject of ventilating foul lime, I am quite certain, had you seen the process in operation properly, you would not have condemned it as you did by attributing the nuisance to its use. The ventilation of foul lime is not new to me. I adopted it at the Berlin works (I think 38 years since), and it worked admirably, and entirely got rid of the nuisance of foul lime.

(To witness:) Do you agree with that or not?

Witness: I do not know what Mr. Evans experienced 38 years ago, but I should judge that the works must have been of a very small size. I understand what Mr. Evans means there is the process, to the full extent, of ventilating the lime; but then you are dealing with 38 years ago, and, no doubt, with very small works. You have to deal here with very large bulks of lime indeed, and that is a great and essential difference.

Mr. ROUND: I am told I ought to read the next sentence:

In the year 1846 it was adopted at the Westminster station at an outlay of £2000 or £3000, and was only given up on my discovery, accidentally, of the renovation of oxide of iron.

We know that oxide of iron is passed away and done with as a purifier, and that was the only reason why it was given up. Do you agree with Mr. Evans as far as that goes?

Witness: I do not know what was the size of the Westminster works at that period, or what foul lime Mr. Evans had to deal with. I only judge from my own experience of the present bulk of lime we have to deal with. In carrying out the experiment of drawing air down through the lime, I was obeying the instructions contained in the directors minute, but I do not know how the matter originated.

Is the exhauster which was used to produce the down draught of air connected with more than one set of purifiers?—It is connected with the whole.

I suppose you often have to open more than one purifier at a time, have you not?—We have sometimes in the winter to open two at the same time.

When that is the case, and when you have to open two at a time, is it not possible that the action of the exhauster might be limited to that one

which presents the least resistance to the down draught of air?—When the sieves of the purifiers are exposed, the air will go through them instead of through the lime, which offers a great resistance; but, notwithstanding that, I have still been obliged to stop the exhauster before being able to empty the bottom tray of the purifier, on account of the heating of it.

Occasionally, will it not happen that one of the purifiers is being discharged without the protection that the down draught of air gives it?—No. To a certain extent it would be deprived of it?—It is exactly the same thing, if you are only opening one purifier. As soon as you expose it, whether it is one or two, the air goes through the opening immediately, without touching the remainder of the lime; it takes the easiest passage for itself.

When you were discharging the purifiers, was the exhauster always left in action, previous to the time when the Referees came?—Yes. I think I have explained to Mr. Harcourt what I have done.

Mr. MICHAEL said he proposed to read the reply of the Referees to that letter from Mr. Evans.

Mr. VERNON HARCOURT: Then I think the whole of Mr. Evans's letter should be read.

Mr. ROUND: Very well. I will take it up from the point where I left off.

We had for years previously been in the habit of burning refuse lime in an oven, and re-using it for purification, so as to diminish the amount of material to be removed; all this was expensive, and was got rid of by the use of oxide of iron. I believe this to be so far the best method of purification; but then you three gentlemen say that we must reduce the sulphur in the gas by some 8 or 10 grains, not, I believe, from any conviction of its necessity, but simply to meet not even the outcry of those who burn the gas, but of a few agitators in the Board of Works and the City Corporation. Now, when I was a Referee, I steadily refused to impose conditions on the gas companies which I knew were uncalled for and absurd, and resigned my appointment, worth £700 per annum, before I would be a party to what I considered a direct departure from the spirit of my appointment.

I venture to suggest that the sulphur question is a bugbear raised by Letheby who found it pay to keep it up. It is all very well to say there is no nuisance from foul lime. I contend there is, and when the time arrives when some of our people are killed (and many are often rendered incurable now) a coroner's jury may bring in an awkward verdict against our engineers for using this process. In little works, as at Silvertown, the purifiers are small, and easily and quickly changed; but when you have to deal with 800 to 1000 bushels of refuse material, it is quite another affair. It is like the earth closets for a small village, and its application to London or any large city.

In a sanitary view, I believe, a little sulphurous acid would do good, but you will never get enough to do any good from the combustion of coal gas, even with 40 grains. It is a curious fact that these few grains of sulphur appear to have a wonderful effect, while nothing is said about the carbonic acid produced by the combustion of a foot of gas (nearly one foot), and yet this is, after all, the great source of evil, where gas is burnt without a proper ventilation of the room. All this should be shown up to the public, and it was my intention of so doing had I remained in office. I trust, however, the day is not far distant when we shall get rid of this lime nuisance, which at present is a thousand times greater than that the sulphur in gas produces.—I remain, &c.,

F. J. EVANS.

Mr. MICHAEL: The following is the answer, written Dec. 30, 1876:—

My dear Sir,—I am obliged by your letter of the 28th. I attributed the nuisance at Shoreditch mainly to the nuisance of the ventilating process, and I did so in consequence of what you and Mr. Clark told me of the peculiarly nauseous smell which had there resulted from the overheating of the purifying material, and which you attributed to the action of heat on naphthaline. By all means introduce this process at all your works if you have not already done so. I have seen it at work on several occasions, and have never myself seen any approach to an overheating of the lime, or of the oxide through which the air is expelled. By keeping the lime damp, and drawing enough air through it, I believe the ill effects on the workmen and the nuisance to the neighbourhood, may be altogether avoided. I regret, however, as you do, the disuse of oxide, which I regard as far the best agent for removing sulphuretted hydrogen.

You have three impurities to remove—sulphuretted hydrogen, for which oxide should be used; carbonic acid, which needs lime, unless Hills's process proves to be better (or unless it should pay better to leave the carbonic acid in, and make up for the loss of illuminating power by a large dose of cannel); bisulphide of carbon, which can be removed by lime fouled for the purpose, and needing only to be changed at considerable intervals.

Your estimate in the difference of the amount of sulphur, according as the gas is purified with oxide only, or with lime as at present, at 8 or 10 grains, surprises me. The present average is about 15 grains; the average with oxide is between 30 and 35

grains; the difference is from 15 to 20 grains. Which of the three statements do you dispute, or how comes your estimate to be half of mine?

I have read with satisfaction the Bill which you are about to introduce for abolishing the sulphur maximum, because if this obligation is to be taken off the companies it should be by the action of Parliament. It is the manifest intention of your present Act that you shall do two things—first, remove sulphuretted hydrogen wholly; secondly, remove other sulphur as far as practicable, within reasonable cost or difficulty, and without occasioning a nuisance. I think the Referees duty is not to judge whether the reduction of sulphur is desirable, but how far, being desirable, it is practicable.

Very truly yours,

A. Vernon Harcourt.

By the Committee: By the oxide process the lime would remove the carbonic acid after the sulphuretted hydrogen had been removed by the oxide. There is no sulphate of lime formed there.

Mr. *Horatio Brothers*, examined by Mr. Michael.

I am the engineer of the western division of The Gaslight and Coke Company, and also a member of the Institution of Civil Engineers. I have had upwards of 30 years experience in the erection and management of gas-works. At the period of the amalgamation of the Equitable Company with the The Gaslight and Coke Company I was engineer of the former company, whose works were in Lupus Street, Pimlico. At those works we used oxide of iron for purifying our common gas. During the 12 years that I was the engineer of those works I do not remember any nuisance being complained of; in fact, I was complimented by the inspector upon the manner in which the works were conducted, and the freedom from smell. The works were in a densely populated and highly respectable neighbourhood, being situated just at the back of St. George's Square. The amalgamation of the Equitable with The Gaslight and Coke Company took place in 1871, and in 1873 we became subject to the restrictions that were imposed upon the latter company. Then I began to use lime moderately; but directly I began to use it in a larger quantity we had complaints from the surrounding neighbourhood, especially when the wind blew from the east or south-east over St. George's Square. In close, damp weather the complaints were more numerous. I do not believe in the theory of dust being carried from the purifiers, because I never found it so. On a wet day, no doubt, it would arise, and be carried, probably—the wind being in a higher quarter—over a greater distance; but St. George's Square is so very near, and the tops of the houses, I might almost say, abut upon the works. Complaints were made by authorities of the parishes of St. Margaret and St. James, and they sent their medical officer—Dr. Barnard Holt—to view the management of the station, and he made a report to the vestry. From previous experience I felt that the use of lime at Pimlico would result in a complaint of nuisance. Thirty-three years ago I used lime (before oxide was invented) at the Salford Corporation Gas-Works. They used it solely there, and in 1858 the nuisance became so great from the large quantity of gas being made, owing to the increase of the population, that, hearing the oxide purification was in vogue in London, the Gas Committee sent me up to make inquiries, and after those inquiries we came to the conclusion to use oxide instead of lime for the sulphur. I find that, after all the care I have taken at Pimlico, it is impossible to avoid a nuisance if the use of lime is to be continued. In 1872, upon the amalgamation of the Western Gas Company with The Gaslight and Coke Company, I was appointed engineer at the company's station at Kensal Green, which was in such a dilapidated condition as not to be able to comply with the requirements of the Referees, and some time was allowed in order to reconstruct the works, and to put up better purifying apparatus. I have carried out the instructions of the Referees, and have been generally able to keep down the quantity of sulphur, although occasions have arisen where I have been unable, as there always will be. The Pimlico station is in a very low part of London, abutting on the river, in a very densely populated neighbourhood, inhabited by highly respectable persons. The Kensal Green station is in the country, with a population around it of the labouring class, and the purifiers are a long way remote from the habitations; the smell is, therefore, not very perceptible, because the houses are so far off. Living on the works myself,

when the wind is in the direction from the purifiers to my house, I smell it very badly. We have about 6000 yards of refuse lime every year to get rid of, and we are now completely stopped in the disposal of it. I have advertised in all the local papers down the line on the Great Western Railway, and I have offered to put it in barges and trucks free of expense, and yet I cannot sell a single load. I do not see how it is possible to be continued to a very much larger extent, for I have in my place between 10 and 12 feet in depth of refuse lime. I do not know of any other mode of getting rid of the sulphur compounds but by the use of lime. I have never known of an instance where lime has been used as a purifying medium without its creating a nuisance; but where it is on a small scale, of course, the nuisance is not so great as it is on a vast scale, like we have it in London.

Cross-examined by Sir E. BECKETT: I do not propose to get rid of the nuisance of lime altogether, but simply to use it for taking out the carbonic acid. The lime would be innocuous then, and there would be a very small quantity compared with what we now have—I should think somewhere about one-third. It would be of some value upon heavy lands in farming, and I should be better able to sell it or give it away, because it would be free from smell. The difficulty now is that persons will not take it, because of the smell arising from the use of it.

Mr. RICHARDS said the letter of the Referees had produced a painful impression upon the minds of the company's engineers, because it seemed to have reflected upon their conduct, and they were rather anxious to repudiate anything of the sort. They were all present for examination if the committee wished it.

The CHAIRMAN: Do you think it will advance your case much?

Mr. RICHARDS said he did not think it would, although it would satisfy the committee that each one of them had made an honest *bonâ fide* effort to carry out the directions of the Referees to the very best of his power; to effect purification by lime without causing a nuisance and yet had failed to do so. There was no ground for suggesting that they had ever been trying how not to do it.

Sir E. BECKETT said it would not be the business of the Referees to give directions. The only mistake which the Referees had made, in his opinion, had been in yielding to the companies. It would have been much better to have said to the engineers, "It is not our business to say how the manufacture of gas is to be conducted; if you do not do it in a proper manner we shall judge for ourselves, and give the required certificate accordingly."

Mr. ROUND said that, on the part of the Referees, he did not impute anything to the engineers of the company. They had to deal with the uniformity or the want of uniformity in the system which those gentlemen individually had to carry out, and they never in any way desired either to say, or to wish it to be inferred in the slightest degree, that there was anything derogatory to them or to their individual ability, but to the system as it had been carried out by them, doubtless in obedience to orders.

After some conversation, during the course of which the letter of the Referees, dated April 20, 1877, was again read,

Mr. RICHARDS expressed himself satisfied that there was not any imputation cast upon the engineers.

Mr. *George Carless Trewby*, examined by Mr. RICHARDS.

I am the engineer at the Beckton station, and also a member of the Institution of Civil Engineers. I have been engaged in the manufacture of gas for a quarter of a century. The Beckton works are by far the largest in the world. The site there has been made up to a very great extent with spent lime, partly derived from the operations on the works, and also from lime brought from other places. During the last twelve months we have covered something like 10 acres. The other stations have no other place to deposit it but Beckton. Taking the average for the last twelve months, the depth has been from 6 to 9 feet, spread over 10 acres. If the present system of lime purification is continued at Beckton, and if we have to find space for the refuse lime, and the gas supply goes on increasing, the quantity to be deposited at Beckton will be upwards of 100,000 cubic yards

per annum; and when we extend our buildings we shall have to excavate it, and remove it elsewhere.

Mr. RICHARDS: Will not danger arise from so large a deposit fouling the watercourses?

Witness: Yes; We have had an action already commenced against us for fouling a watercourse. It is almost impossible to prevent percolation.

Have you found the difficulty of getting farmers and other persons to take away the refuse lime?—Yes; there is a very limited demand for it.

In point of fact, the only place where the company can deposit it at present is the Beckton works?—That is so. I have heard the evidence given as to the nuisance created by this lime, and I endorse every word of it. By the old process of peroxide of iron, a certain quantity of lime was used to take out carbonic acid, but no nuisance was caused. I have worked both systems.

Cross-examined by Sir E. BECKETT: The refuse lime has been accumulating ever since the Beckton works were started, five or six years ago. In 1875 the filling in of the lime simply kept pace with the increase of the works, but the amalgamation with the Imperial Company had not then taken place.

Sir E. BECKETT: Did you suggest to anybody in 1875 the expediency of getting rid of this accumulation?

Witness: We were in hopes, if we addressed a proper representation to the Referees upon the matter, that they would give us relief.

Then you complain personally of the action of the Referees, and not of the system? Is that so?—Well, I take the two things combined together.

But is it the two things combined together? You say that you were in hopes, in 1875, that a proper representation to the Referees would give you relief?—In 1875 the question of the accumulation of lime had not presented itself to our mind.

Of course I cannot investigate your mind, but the fact is that the lime was increasing at a known rate, was it not?—Just so.

Well, the lime increasing at a known rate, and you, being before the committee, and discussing the question as an engineer, did not think of asking the committee to set you free from that obligation?—I believe not.

When you talk about the Referees, you knew that the Referees had been in existence before then?—Yes.

Then what it is you are really complaining of now I do not understand?—As far as I am concerned, I am complaining of the amount of refuse lime that is brought down to my station, and also of the nuisance, because it not only affects my health, but it affects the health of the persons who are bound to live upon the works. On a day like this, from inhaling the sulphuretted hydrogen and the sulphur compounds over the whole area of our works, it causes depression of spirits.

Re-examined by Mr. RICHARDS: The amalgamation with the Imperial Company took place in 1876, and it is since some of these stations have been added to The Gaslight and Coke Company that the evil has become much more conspicuous.

By the COMMITTEE: As things are going on at present, I think our spare ground will be filled up with the spent lime in less than three years.

By Mr. ROUND: The land at Beckton is about 6 or 7 feet below the level of high-water mark, and we have been utilizing this lime hitherto for the purpose of raising the level of our land.

Mr. ROUND: I do not wish to underrate the inconvenience you have alluded to, but could you not go on for the next two or three years and rather benefit your property?

Witness: No, because if we extended our works we should have to excavate into the deposit. We are already doing that, and the nuisance to the men is something more than can be imagined.

Do you mean you are already excavating lime that you have in the last two or three years deposited?—Yes.

And you are not depositing in order to raise your land up to the level of high-water mark?—We are depositing it because we have no other place to put it in. For no other purpose.

But there must be many parts of your property at Beckton which it would be desirable to raise to a higher level than they are at present, are there not?—No, it is already done.

Dr. *Thomas Stevenson*, examined by Mr. MICHAEL.

I have been Medical Officer of Health for St. Pancras for nearly nine years. In the autumn of 1875 it was brought to my knowledge, by the inspector of nuisances and others, that there had been complaints going on for some time with regard to the nuisance arising from the gas-works at King's Cross. The complaints were serious, and in the month of December I called on Mr. Chubb, and I went on the same day to the works; I also visited them several times subsequently. I found a great stench arising from the works, and I learnt from Mr. Chubb that it arose from the fact that they were obliged to use lime in the purification of the gas. I was well aware of that fact, so I made myself thoroughly acquainted with the works. I saw the lime purifiers opened, and there was a very powerful odour during the operation. The odour of sulphuretted hydrogen and ammonia was very strong near the purifier, and I could detect sulphuretted hydrogen outside the works, in the neighbouring streets; but upon investigating more I found that the nuisance extended to a very considerable distance—even to Argyle Square, which is 600 yards south of the works, where no sulphuretted hydrogen could be detected. I say that undoubtedly there is something besides, or in addition to, the sulphuretted hydrogen causing the nuisance, for when the nuisance has been at the worst, you could detect, by various means, sulphuretted hydrogen on and about the works; but, after going a certain distance from the works, you could not detect any sulphuretted hydrogen, and then the peculiar odour of this gas lime—this sulphate of calcium—came out.. I cannot say that a smell of such a kind is injurious to health, neither can I obtain any distinct evidence of it, but it is a very disgusting, disagreeable smell, and very annoying. A small quantity of sulphuretted hydrogen will produce powerful effects. There are various experiments recorded where, if it exists to the extent of one per cent., death is the result. I have had cases within my own experience where great danger to life has ensued from inhaling sulphuretted hydrogen. That occurs when it is liberated in any way, especially from chemical causes. I asked the authorities of the then Imperial Company to carry out certain plans which I thought would modify, or, in a great measure, abate the nuisance. Those were ventilation of the purifiers before employing them, if possible, by the passage of carbonic acid through them, with the subsequent passage of the air which is drawn through the purifiers, through oxide of iron, or a furnace, in order to get rid of the foul gas from the purifiers; practically the mode, such as has been described and illustrated upon this model. My proposals were not carried out on those works. Plant was put upon the works to do so, but in consequence of what I heard as to the effect of the process at other works, I did not insist upon my proposals being carried out. I went down to Bromley, and saw the effect. There had been great heating of the purifiers, by which they had been materially damaged. I was also shown certain apparatus, which I was told had exploded through carrying out this system of purification, and was told by Mr. Wright, the engineer, that the rubbish arising from carrying out the process was so great that the cure was worse than the disease. I do not think that any such quantity of sulphur as would be left in the gas, after careful oxide of iron purification, would result in injury. I work in a laboratory where gas, purified by the old oxide process, is used. I tested the gas almost continuously during the months of February and March last, and I found, on an average, 38 grains of sulphur per 100 feet. I have not found any injurious effects to my health from the use of such gas. I do not think, if the amount of sulphur does not exceed 40 grains, it would cause any serious amount of injury. I have made a series of experiments, by which I am enabled to give that evidence, the results of some of which have been already given on the previous Bill.

Cross-examined by Sir E. BECKETT: If there is not free ventilation, even 15 grains might cause a considerable amount of damage and discomfort, but I do not think the difference between 15 grains and 35 grains

would require any material increase in ventilation, because the sulphur would be so small in effect.

Sir E. BECKETT: Then you think that the company might safely be left to the 40 grains, do you?

Witness: I think that 40 grains would exercise no prejudicial effect.

Then I am afraid this committee must have made a great mistake upon the other Bill?—That is not for me to express an opinion upon.

The COMMITTEE: You do not deny that there is some difference in the inconvenience and the nuisance between 20 grains and 40 grains?

Witness: I have not been able to perceive any appreciable difference in burning the two gases.

That is a question of ventilation, but you will not deny that, under the same conditions as to ventilation, there would be a considerable difference?—I deny that there would be a considerable difference. I found in my experiments about 5 per cent. of the sulphur was converted into sulphuric acid, but the difference between 5 per cent. on the 15 and 30 grains, I think, would not be material.

Do you mean to say, supposing you burnt gas with 15 or 20 grains, under the same conditions that you burnt gas containing 40 grains, that there would be no difference?—There would be a difference, but it would be so small, I think, that the effect upon health and upon the destruction of furniture, and so on, would not be appreciable, and I do not think the difference could be weighed against the nuisance arising from the lime method of purification.

By Mr. ROUND: I did not communicate any of these complaints to the Referees; I have acted for my own Sanitary Committee, and I have nothing to do with the Referees.

TUESDAY, MAY 15.

M. *Felix Le Blanc*, examined by Mr. RICHARDS.

(Mr. ALBERT sworn as Interpreter.)

I am a Chevalier of the Legion of Honour, Professor of Analytical Chemistry to the Central School of Arts and Manufactures in France, a Member of the Council of the Society for the Encouragement of National Industry, and have been engineer-in-chief for the verification of the gas supplied to the Municipality of Paris since 1863. I know all the conditions arranged in the treaty made between the Municipality of Paris and the Paris Gas Company. Those conditions were drawn up between M. Dumas on the part of the town, and M. Regnault on the part of the company. My duty is to see that those conditions, so far as they relate to the testing and verification of the gas, are obeyed and carried out under Article II. The reports are made 24 times a month, at 11 offices, corresponding to the seven gas-stations in the City of Paris, and I produce the report of one day's experience at all the stations. The Paris Gas Company have not only fulfilled all the obligations imposed upon them by the treaty, but in many instances they have gone beyond those conditions, by supplying a better gas than they were obliged to do. The following are the requirements as to purity:—"The efficient purity of the gas shall be stated or proved by bands of white paper not starched, which have been previously prepared by dipping the same into a solution of neutral acetate of lead, in distilled water, containing one of salt per hundred of water. These strips of paper shall remain in a current of gas during the duration of one of the relative trials or tests of the illuminating power—that means to say, one quarter of an hour—and if they shall not get brown the purity is perfect. This test, anyhow, shall be made in conformity with the prescribed instructions of MM. Dumas and Regnault." The paper must not even get yellow; that is the only condition as to purity. I can state, from my own knowledge, that before the treaty was concluded there were continuous complaints, but at the present time those complaints have ceased to be preferred, and for several years none have been made. It is very seldom indeed that the examiner finds any discoloration of the paper, which otherwise would be the subject of a fine. The gas is purified with oxide

of iron, which is generally prepared with sulphide of iron and lime; and a current of water and air is carried through. It is well understood that the deposit of tar and ammonia is found in the purifying-boxes; however, no conditions as to that are imposed upon the company. The company have never used lime alone in Paris. I believe that the company find it to be to their interest to employ oxide of iron, because not only the sulphur, but the sulphuretted hydrogen, is entirely absorbed by it, and also because there is economy in it, as the purifying materials, when they have been used for some time and get black, are put upon trays. Then there comes the revivifying process, when that iron with the sulphur is oxidized and can be used again.

Mr. RICHARDS: Do you think the use of lime would prove a nuisance in the City of Paris?

Witness: I am not a medical man; but in London, when I went to Beckton, to where the purifying-boxes were open, I found a smell which was very disagreeable. In Paris I found that the purifying material gave off a smell, certainly, but it was more an ammoniacal smell, and not such a fœtid smell as in London; and the medical men over there constantly apply to the company to allow invalids, and people who suffer from cough or whooping-cough, to inhale those vapours, but I will not guarantee the efficiency of that. I have never found any smell of sulphur in rooms in which gas is burnt in Paris. I must, however, state that there is a very slight acidity in the products of combustion; there is a small amount of ammonia, but the treaty does not prohibit that. In the combustion there may also be formed a small quantity of sulphurous acid, but so small, indeed, that nobody takes the slightest notice of it, and it never gives rise to any complaints from the consumers. There are only a few libraries in Paris, to which readers are admitted, where gas is burnt in the evening, and the librarians do not make any complaint. If there were any complaints, they would be made to the Prefect of the Seine, who would send them to his engineers. Another remedy is that a suit can be instituted against the gas company. I know the celebrated shop of MM. Christophel, who are silversmiths, and do silvering and gilding. Before the treaty which was entered into between the company and the City of Paris they thought it to their advantage to make their own gas. Their purpose was to have gas entirely free from sulphur, and that gas was made by decomposition of water by charcoal. Since the treaty they have given up making their own gas, but they have never complained either to the company, to the town, or to the engineers. It is quite evident, in case the gas contained sulphur, that it would, the moment they opened the tap, have an effect upon the silvering process. I beg to say, also, that the purpose or object of the commission, by which the treaty resulting from it was made, was that a certain quantity of ammonia should be allowed in the gas.

In the discussion before the treaty was made, was the question of the presence of sulphur compounds, other than sulphuretted hydrogen, discussed at all?—Although nothing appears upon that point in the treaty, still I will tell you what occurred from what I have heard stated by M. Dumas.

Can you tell us of your own knowledge anything which took place with reference to the discussion upon the sulphur compounds?—There is a certain quantity of ammonia which is allowed to exist favourable to the purification of the sulphurous compounds, and I will tell the reason. Sulphide of carbon, for instance, in the presence of ammonia, is much better kept or held in the purifying-boxes. Chemists know that the sulphide of carbon acting upon the ammonia can easily produce sulpho-cyanide of ammonia; therefore this is a system to prevent the sulphide of carbon mixing up with the gas. Sulpho-cyanide has for some time been employed for photography, and the man who buys from the company the old material from the purifying-boxes extracts that sulpho-cyanide of ammonia for sale as a matter of business. After a great number of these purifying processes have taken place, then it is sold to M. Conchatt.

Mr. RICHARDS said a report had been sent by M. Dumas to the President of the Board of Trade, which he proposed to lay before the committee, and, after a short discussion, it was read, as follows:—

Institute of France, Academy of Sciences,
Paris, May 1, 1877.

Mr. President,—Lord Lyons having informed me of the desire of the Government of Her Majesty the Queen to know my opinion upon the gas question, I have the honour to send it to you, and to beg you to communicate the same to the committee charged with the Bill of The Gaslight and Coke Company.

Accept, Mr. President, the assurance of my respectful sentiments,

J. B. DUMAS, the Perpetual Secretary of the Academy.

Opinion of Monsieur J. B. Dumas, late Minister of Agriculture and of Commerce, Great Cross of the Legion of Honour, Perpetual Secretary of the Academy of Sciences, Vice-President of the Superior Council of Public Instruction.

I was one of the Municipal Council of the City of Paris during sixteen years, and I have had the honour to preside over it during more than ten years.

In this capacity I have often had to occupy myself with questions relating to the manufacture of gas for lighting purposes, to the verification of its practical qualities, and to the consequences of its use.

I have been especially called upon to prepare the treaty which has regulated for sixteen years the interests of the Parisian Gas Company and those of the City of Paris, and to determine the obligations to be imposed upon the company, and the means to ensure their exact performance of them.

Before the treaty was interposed the situation was intolerable.

In consequence of errors committed, the exigencies relative to the appreciation of the illuminating power, and of the absence of control relative to its practical purity, it happened—

1. That every day the company were condemned to 1000 francs fine for insufficiency of illuminating power.

2. That every week the Municipal Council received complaints from the consumers, which denounced the gas as having blackened or darkened plate or brass in the silversmiths shops, or the steel or iron goods, or the plates and dishes, or the crystals in the glass and china shops, and the white lead painting in apartments, as having discoloured or faded the shades of stuffs in the silk shops, as having inconvenienced or made ill the actors or the singers in the *cafés chantants* and the theatres in which the footlights were lighted with gas, the first of these effects being attributable to the sulphuretted hydrogen, and the second to the sulphurous acid produced by its combustion.

In order to end all these disorders, I have asked that a complete verification of the illuminating power of the gas should be effected, and that measures should be instituted in order to ensure its practical purity in a permanent manner.

It is not now the time to explain how these trials, which took more than a year, were conducted and were carried out in a little experimental works for the preparation of the gas, as well as at my laboratory at the Sorbonne, for the verification of its illuminating power and its purity. It will be sufficient to state that the system adopted by the Municipal Administration upon my report having been in operation since the year 1861, did not give rise to any criticism; it notably caused the disappearance of all complaints relative to the insufficiency of the illuminating power, the presence of sulphuretted hydrogen, and of the production of sulphuric acid.

The examiners of the illuminating power only found the gas once, by accident, below its limit; the jewellers and steel and metal dealers, the crystal and crockery merchants, and private individuals having painted panellings in white lead, the magazines of embroidery or of *nouveautés*, the artists of the theatres, never came to complain of the damage or inconvenience which the old gas made them experience.

Therefore it seems certain that, taking simply the practical point of view of the matter, the harmony between the company producing the gas, the authorities which watched over its good quality, and the consumers who used it, seemed to be solidly established; nobody makes complaints.

I leave on one side the economical and financial question, which, however, is full of interest, but which does not touch the sanitary side of the question, nor the control of the fabrication. I restrict myself to state that which concerns this latter aspect of the question.

There were present on the one side the company charged to manufacture the gas, and on the other side the City of Paris, the latter intervening under various titles—

1. As proprietors, possessing the soil in which the company established their canalization.

2. As customers, consuming the necessary gas for the lighting of the streets.

3. As partners, taking part of the profits of the company.

4. As the Municipality, charged to watch, in the public interests, over the strict execution of the clauses of the contract incumbent upon the company.

In order to simplify this situation, and to avoid all interpretations of a nature to be inconvenient to the contracting parties in their respective movements, it seemed to me to be necessary on the one part to leave to the company the most complete liberty for its means of production, and its procedure for purification; on the other part to constitute a sort of tribunal, charged to state legally the purity of the gas which has been distributed for consumption, just as one states the title of moneys put into circulation.

In consequence it was agreed that M. Regnault, representing the company, and I, representing the City of Paris, should establish, in concert, a system of control, and

prepare apparatus to realize this system, the company and the city accepting in advance our mutual results.

In the name of the city, I considered it indispensable to guarantee—

1. A very definite illuminating power.

2. The absence of sulphuretted hydrogen.

I only state, as a passing remark, that the procedure which we proposed in order to control the illuminating power is adopted to-day in a very great number of towns in France and abroad, and that there has been constructed at least 157 apparatus of verification for the purpose.

As to the absence of sulphuretted hydrogen, we thought that the inconvenience of its presence having been rendered sensible by its action upon the compounds of lead, it was sufficient to exact that the gas should remain without appreciable action on paper impregnated with a salt of lead during an exposure of a quarter of an hour.

The question was discussed between M. Regnault and myself, in order to know if it was right or not to exact that the gas should be free from ammonia, and that it should not have any alkaline reaction. Our opinion was that the pressure of some traces of ammoniacal gas was not inconvenient at all for the consumer, that it would ensure the disappearance of the sulphide of carbon entirely or nearly so, and that in consequence it avoided the formation of sulphurous acid at the moment when the gas was burning. As to fearing the presence of an excess of ammonia, there was no occasion to trouble about it, its price engaging the company to gather it out.

Thus we were led to establish that the gas supplied by the company should be coal gas endued with a definite illuminating power, and without action upon the acetate of lead paper. We knew that the gas was alkaline.

For all the rest the company are free to produce their gas just as they think proper, and to purify it in a manner conformed to their interests, or to do it at their convenience, the town reserving to itself only the right of observation, like a partner, in case, by the use of onerous or badly conceived processes, one should happen to bring trouble into its finances, or compromise the profits of the operation. By the wise direction of the company, every remark on that subject, on the part of the engineers of the city, has become useless.

Conformably with these principles, M. Regnault and I have instituted a series of various and prolonged experiments, which are resumed in the practical instructions for the use of the examiners charged with the daily verification of the gas delivered to the public.

These practical instructions have been accepted by the two contracting parties, and have been incorporated in Article II. of the treaty before mentioned, page 11 of the edition of 1871, lines 12 to 20 inclusive, and have been annexed to this treaty, in which they will be found on pages 23 and following.

The stipulations relative to the purity and illuminating power of the gas delivered to the public are found in Article II. of the treaty, page 7, edition of 1871.

This article provides that the gas shall be extracted from coal, that it shall be perfectly purified, that its illuminating power shall be that of a burner consuming 105 litres of gas, giving a light equal to that of a Carcel lamp consuming 42 grammes of purified colza oil.

The experiments established by means of this report embraced the production of gas from all varieties of coal, from whatever source the company could obtain them to ensure their service—French, Belgian, English, and German; for the burner, all varieties of burners known.

M. Regnault and I were constantly assisted, during the long and troublesome work, by two distinguished chemists, M. Paul Audouin, engineer of the gas company, and M. Paul Bérard, secretary of the Consulting Committee of Arts and Manufactures attached to the Ministry of Commerce, who were authorized by us to publish the details.

From these numerous and varied experiments, we have deduced two principles on that which concerns the verification of the illuminating power. The first is, that the gas-burner ought to approach as much as possible in form and flame to that of the Carcel lamp taken for a type—conditions which were found realized in a porcelain burner of the Bengel system.

Second, that the photometric apparatus should be so arranged that the examiner would have only the variable point to determine, all others remaining constant in each trial.

The Carcel lamp and the gas burned which have to be compared having been lighted, the examiner assures himself that the lights have the same intensity, being placed at the same distance from the photometric disc. This equality being established and maintained, the gas-meter is placed at zero, while the Carcel lamp, placed upon the plate of the balance, is kept in equilibrium by a weight of 10 grammes. When it has burned 10 grammes of oil this equilibrium is broken, a bell informs the examiner, who stops the pointer, and who has only to read the figure indicated by the meter to ascertain the consumption. He notes how many litres of gas have been burned in order to produce a light equal to that which 10 grammes of purified colza oil supplied, and, therefore, how much it requires to correspond with the consumption of 42 grammes of oil per hour.

In order to ascertain the state of purity of the gas, we have had recourse, as has been already seen, to the employment of a band of unstarched paper dipped in a solution of acetate of lead, formed of one of salt for 100 of distilled water, suspended in a tubulated bell-glass placed upon a tray. The cock which communicates the current

of gas to the bell-glass is opened, the gas passes into this bell-glass, and circulates there under a pressure of from 2 to 3 millimètres of water during 14 or 15 minutes—*i.e.*, during the time necessary for an experiment to ascertain the illuminating power. After having passed through the bell-glass the gas is burnt.

If after this period of time the paper band has remained white, the gas is considered exempt from all sulphurous impurity of a nature to be injurious to the public—practically it is considered to be purified gas.

Every contravention concerning the presence of sulphuretted hydrogen is the subject of a *procès verbal* followed by a fine.

When the illuminating power is regularly obtained, the obligations of the company towards the city and the public are regarded as having been satisfied. In a contrary case, and after a certain number of re-occurrences, the company are exposed to the prescribed penalties, which not being any longer excessive, as they were before, would be applied with rigour. But their intervention has not been found to be necessary but once in what concerns the minimum of the illuminating power, and one might have believed that in the long run the verification of the gas was useless, because there were so few contraventions.

It cannot, however, be doubted that this verification is indispensable; it has precisely for consequence the prevention of all relaxation in the important service of the lighting of Paris; it has contributed in the highest degree to maintain the company in the excellent line of conduct which they have adopted from the commencement, and have persevered in hitherto.

During more than ten years as President of the Municipal Council, it was my duty to state officially the results obtained by the application of these measures taken altogether. Since I have ceased to fulfil these duties in 1870, I have been enabled, by official communications, to keep myself informed of everything which is of interest in a service, at the creation of which I had taken so important a part, that it was not possible for me to lose all interest in it. I have, therefore, the right to affirm that the treaty, in the preparation of which my public duties and my special studies had furnished me with the occasion to participate, under various titles, and had the happy fortune to consecrate the liberty of action of the company to supply each year an important contribution to the finances of the city, to guarantee in all points of view the public interest, to increase the proportions of light placed at the service of the public ways, to decrease the price of gas, and to make disappear all appreciable damage to the consumer.

(Mr. ALBERT verified the copy handed in as being a true translation of the original.)

Cross-examined by Mr. CRIPPS: The paper bands dipped into a lead solution are used for the purpose of ascertaining whether the gas is free both from sulphuretted hydrogen and from ammonia. The only difference between the French and the English systems is that the paper is saturated with moisture in order to absorb more upon the paper; to make the paper more sensitive to it.

Mr. CRIPPS: But all that difference between the English and the French systems is still only directed to the test for sulphuretted hydrogen?

Witness: For all materials which attack or make an impression upon the lead solution.

Have you made any experiments to determine the quantity of sulphur compounds in 100 feet of coal gas in Paris?—No; such an experiment I should consider a weak one.

You know nothing at all of the quantity of sulphur compounds contained in the Paris coal?—I do not study that question; my duties are simply to see that the conditions stipulated for in the treaty are strictly observed.

So long as the conditions of that treaty are performed, you have nothing further to do with the matter at all?—I have other duties to perform, certainly, but nothing more as to the purifying process.

The CHAIRMAN: I am certainly rather fresh in chemical combinations, and I am not sure whether I follow the evidence. Am I right in thinking that in Paris they are allowed a certain amount of ammonia in their gas, with a view to neutralizing the effect of the sulphur compounds—is that so?

Mr. MICHAEL: What he absolutely said was this: We do not so much care about taking out the whole of the ammonia, because, retaining a small amount of ammonia in the manufacturing process would not prevent the fixture of a certain quantity of sulphide of carbon in the process of purification. (To witness:) Is there any limit to the ammonia allowed in the gas in Paris?

Witness: That is not expressed in the treaty, but I can state that I have discovered, in my examinations, it was about the tenth part of a

milligramme per litre, which is the same thing as a decigramme to a cubic mètre; there are 1000 litres in a cubic mètre.

The CHAIRMAN: That is 5 grains in 100 cubic feet?

Mr. KEATES: About 4½ grains.

Mr. MICHAEL: One grain and a half in 35 cubic feet.

The CHAIRMAN: All you are allowed in London is 1½ grain.

Mr. RICHARDS: At the present moment it is 2½ grains.

The CHAIRMAN: Then it is nearly twice as much in Paris.

Mr. RICHARDS: If only half the quantity of ammonia which is in the Paris gas were to be allowed in that gas, would it have any effect upon the sulphur compounds?

Witness: My own opinion, and also that of M. Dumas, is, that the presence of ammonia has an effect, which is to retain the sulphur compounds, or, perhaps, the other sulphurous compounds, or matters not well known. We are not under any fear that the company would give a supply of gas so much impregnated with ammonia, because it is a source of profit to them to retain, or to separate as much as possible, the ammonia, which is a source of profit to them.

By the COMMITTEE: There are two things to be considered—first of all, whether the ammonia should be in sufficient quantities to prevent the acidity of the gas before it is lighted. When the lighting takes place, then the ammonia itself is decomposed, and, even if there could result from it, a trace of nitric acid; and for this reason it would be inconvenient to increase the quantity of ammonia.

Mr. MICHAEL: The witness has not stated whether the presence of ammonia has any influence in preventing any of the bad influences when sulphur is present during the combustion.

The CHAIRMAN: I will put the question in this way. It has been proved to us, or we have had evidence, that in the combustion of the London gas, the sulphur compounds produce sulphuric acid, and this sulphuric acid has an injurious effect upon furniture, gilding, and the binding of books. Supposing that is so, do you think that the presence of the amount of ammonia allowed in the Paris gas would prevent that, or neutralize it in any way?

Witness: No; the ammonia disappears in the combustion, and cannot afterwards give any alkaline produce. The presence of ammonia has been considered useful in the passage of gas through the purifiers to retain the sulphurous compounds, which otherwise would escape. I think that the English chemists who are interested in this question have occupied their minds a great deal with the sulphuric acid question consequent upon combustion. I think there is something very much more pernicious, or hurtful, or injurious, and that is the presence of a very small quantity of sulphuretted hydrogen in the gas; and this is the reason why we keep strictly to an absolute purifying process.

Mr. CRIPPS: I asked the witness whether he had made any experiments by which he could determine how many grains of sulphur compounds there would be in the Paris coal in 100 feet of gas. He said that he had not made any experiments, but I am told that I did not make it quite clear; and I want to know whether he knows that matter from his own experiments or from any other source?

Mr. MICHAEL: We are going to call Mr. Ellissen.

The CHAIRMAN: In the report, he refers to the stipulation in the English private Act forbidding more than 20 grains, so that he is conscious of the thing.

Mr. MICHAEL: When the gas is perfectly free by purification from sulphuretted hydrogen, do you attach any importance to the sulphur compounds, other than sulphuretted hydrogen, which may be in the gas when it is burnt?

Witness: It is evident, if there are notable quantities of these compounds in it, that the combustion, giving sulphurous acid—which oxidizes itself, to give afterwards sulphuric acid—must have some inconveniences; and on that subject there would be complaints in the shops where there are coloured stuffs, which would be affected by the sulphuric acid; and those complaints have not been made. I must observe, however, that I have not studied the London gas, nor the coal from which it is made. I know

the French procedure of making gas, and I come to explain and to justify that which is done in Paris.

By the COMMITTEE: The Paris Gas Company buy coal of very different kinds. There is in connexion with the largest gas-works in Paris an experimental work where every quality of coal is examined, and also the products therefrom, and the different kinds of purification. The company know beforehand the kind of gas that will result, and, therefore, they care as little as possible to employ pyrites coal, which produces those sulphurous compounds.

As a matter of fact, the coal which is used for the production of this Paris gas is wholly free from the ingredient which makes the sulphurous compounds?—That would be impossible. I am not admitted to the management of the Parisian Company; but the control of what is supplied by them is in my hands, and as long as I see that the conditions of the treaty are obeyed, then the manufacture of the gas, and the coal, or any ingredient, does not concern me at all.

You have said that there is an experimental work where they try the coal before they use it, in order to ascertain whether it is the kind of coal which would produce much sulphur. Can you suggest any reason why, after so trying them, they should select the coal which would produce the least sulphur?—Their interest is that the purification process should not be made too difficult.

Is the check upon the company using a very sulphurous coal that they would apprehend complaints being made of the sulphurous compound after it had been supplied to the consumers?—This consideration would be rather too limited. In the purchase of coal and other materials the company have different points in view.

What are those points of view?—The nature of the manufacture, the illuminating power of the gas, the accessory produce, the quality of the coke—in fact, everything which makes the manufacture advantageous with the materials given for it. However, of all this I am not a judge; but the engineers of the company are, who pronounce thereon.

M. *Albert Ellissen*, examined by Mr. MICHAEL.

I am a Chevalier of the Legion of Honour, and a chemical engineer. I was formerly engineer of the Paris Gaslight Company, and also chief of the experimental works, which were erected in the ordinary works at Villette, to ascertain the value of the coals, and to make certain experiments in the processes of the manufacture of gas. I am at present practising in Paris independently as a consulting gas engineer. I am also a director of the Madrid and some other gas companies. I was the chief engineer of the experimental works for about 10 years, and quitted the service of the Paris Gaslight Company in 1871. I am thoroughly well acquainted with the theory and practice of gas-making, as performed both in France and England, and also with the mode of purification adopted in both countries, I am also well acquainted with the treaty which was entered into between the City of Paris and the Paris Gas Company, referred to at length by the last witness. There is no other test adopted in Paris as to the other sulphur compounds in the gas after it is free from sulphuretted hydrogen.

Mr. MICHAEL: Have you yourself made any tests as to the quantity of sulphur remaining in the Paris gas after purification from sulphuretted hydrogen had been carried to its full extent?

Witness: I made some experiments in 1864. I was asked by the English companies to come over and make some experiments on the London gas, and when I when back to Paris I made some experiments, not on the Paris gas, but on a special gas at the experimental works. What I intended to do was, not to have the absolute quantity of sulphur, but only to see how the several products would act on the sulphur; so that it was not to make a test of the Paris gas, but only to make a test of a special gas made at these experimental works. The coals employed by the Paris Company are of all sorts—English, French, German, and Belgian. It is certain that Belgian coals are much more free from pyrites than the general English coal. Before the war, the Paris Gas Company used a great quantity of English coal—sometimes one-half—in their works. They have

still contracts for English coals, and I think that they have now is for Pelaw Main and other coals which are used for gas manufacture in England.

Mr. MICHAEL: In the experimental works was it a point with you to ascertain specially the freedom from sulphur in the gas?

Witness: That was not at all my occupation, and the Paris Gas Company never did make experiments on this point. The only thing done at the experimental works was to know the value of the coal—which is one of the great points—to see what was the production of gas and coke, and then to see if the Paris gas corresponded to the products obtained.

As far as you know in Paris, has there ever been any question except freedom from sulphuretted hydrogen in the gas?—No; there has never been any other question.

Has there ever been any trouble from the presence of sulphur compounds in the gas, after the gas has been purified from sulphuretted hydrogen?—I never heard of any trouble.

Supposing that any bad effects had resulted from any sulphur compounds left in the gas after the purification from sulphuretted hydrogen, would you have been likely, as the engineer of the gas company, at once to have heard of such complaints?—The directors of the company would have sent to the experimental works to make experiments about it; but no such experiments were made.

Have you ever yourself seen any bad effect resulting from the use of the Paris gas, owing to sulphur compounds other than sulphuretted hydrogen?—I have never seen any effects. I know all the places in Paris, and I never heard of any bad effects.

Examination continued: The quantity of gas used in the Paris shops is so immense, and also where the pictures are, and the Opera House, and so on, that there would be a complaint if there were any compounds from sulphuric or sulphurous acid deposited. In the Louvre they burn something like 70,000 cubic mètres in a night, and Beaumarchais about the same quantity. There is no test at all in Madrid, nor, as far as I know, in any town on the Continent, except the one that is in use at Paris, for sulphuretted hydrogen. I know all the contracts made between the towns and the companies, and, excepting England, there is not one stipulation about sulphur compounds other than sulphuretted hydrogen. In Madrid they use a great part of English coals; in Italy they use English coals—there are sometimes stipulations made about that—and the last treaty of Bordeaux, made this year, does not contain any stipulation of that sort. Oxide of iron is the only thing which has been employed in Paris for some 20 years to get rid of sulphuretted hydrogen. Lime was previously used to take out all the sulphur of the gas; but since oxide of iron has been known in the manufacture of gas, all the gas-works that I am aware of use only oxide of iron. I have seen the works at Pimlico, at Shoreditch, and at Beckton, and I am sure they would not in Paris allow working lime on that scale; it would immediately be stopped by the Prefect of Police. I have here some tables of experiments I made with respect to the quantity of sulphur in gas.

The following tables were delivered in:—

Hornu (Belgium) Coal, containing 15·05 lbs. of Sulphur per Ton distilled at a Low Temperature.

Length of Time of Distillation.	Yield of Gas per Ton of Coal.	Rate at which the Gas was consumed.	Sulphur in 100 Feet.
6 hours. . .	8,610 feet. . .	1·010 feet. . .	6·07 grains.
6 „ . .	8,610 „ . .	1·010 „ . .	6·28 „
6 „ . .	8,300 „ . .	9·734 „ . .	6·29 „
6 „ . .	8,300 „ . .	0·734 „ . .	6·54 „
7 „ . .	7,800 „ . .	0·819 „ . .	5·91 „
7 „ . .	7,800 „ . .	0·819 „ . .	6·10 „
7 „ . .	7,200 „ . .	0·833 „ . .	7·65 „
7 „ . .	7,200 „ . .	1·416 „ . .	2·762 „
7 „ . .	7,820 „ . .	0·988 „ . .	5·567 „
7 „ . .	8,190 „ . .	0·865 „ . .	6·247 „
7 „ . .	7,920 „ . .	0·812 „ . .	4·675 „

Denain (French) Coal, containing 31·10 lbs. of Sulphur per Ton, distilled at a Low Temperature.

Length of Time of Distillation.	Yield of Gas per Ton of Coal.	Rate at which the Gas was consumed.	Sulphur in 100 Feet.
7 hours. . .	8,610 feet. . .	0·688 feet. . .	5·227 grains.
7 „ . .	8,610 „ . .	0·589 „ . .	4·037 „
6 „ . .	8,290 „ . .	0·861 „ . .	1·742 „
6 „ . .	8,030 „ . .	0·593 „ . .	2·720 „

Same Coal at a High Temperature.

4 hours. . .	9,770 feet. . .	1·829 feet . .	1·360 grains.
4 „ . .	9,770 „ . .	1·589 „ . .	1·232 „
4 „ . .	9,850 „ . .	0·727 „ . .	5·525 „
4 „	10,410 „ . .	0·882 „ . .	6·332 „
4 „		0·893 „ . .	7·480 „
4 „		0·575 „ . .	4·420 „

Escouffiaux (French) Coal, containing 18·80 lbs. of Sulphur per Ton, distilled for Four Hours at a High Temperature.

11,320 feet.	3,390 feet 1st hour. . .	Products lost.
	1,624 „ 2nd „ . .	12·937 grains.
	2,082 „ 3rd „ . .	11·021 „
	3,072 „ 4th „ . .	13·068 „
	Average	12·342 grains.
11,270 feet.	2,360 feet 1st hour. . .	7·362 grains.
	3,001 „ 2nd „ . .	5,968 „
	3,001 „ 3rd „ . .	6·229 „
	3,425 „ 4th „ . .	5·881 „
	Average	6·335 grains.
11,550 feet.	2,076 feet 1st hour and 45 min.	7·666 grains.
	1,907 „ 2nd „ 53 „	6·273 „
	Average	6·969 grains.

Mr. MICHAEL: Will you explain to the committee what was the test you made use of with respect to sulphur?

Witness: I made experiments in London, to see what was the real quantity of sulphur in the gas at that time, and to see if there was a practical way to take the sulphur out, or to reduce it. I tried it in a laboratory by all the tests that are used at this moment, and I did not find that there was any practical way to take the sulphur out. What was proposed at that time was lime, as it is now, but I did not think that lime could be used on a large scale in a city like London. The other process, I think, was that of Mr. Bowditch, who proposed to heat the gas to get out the sulphur compounds which are not sulphuretted hydrogen, and afterwards to take the sulphuretted hydrogen out, but I do not think it is possible to do that on a large scale. It is quite impossible, in manufacturing gas, to raise it to a regular heat without destroying the illuminating power.

Is there anything whatever done in the process of the manufactures of gas in London that would make a larger quantity of sulphur compounds in the gas, other than sulphuretted hydrogen, as differing from the mode adopted in Paris?—I think just the contrary. When I was in London, in 1864, they were heating at a much lower temperature than we were in Paris; and the experiments show that, if you produce gas at a higher temperature, you have more sulphur in the gas than if you produce it at a lower temperature; so that I think all the conditions of London ought to produce less sulphur than if we distilled the same coal in Paris.

Owing to greater heat employed in the distilling process in Paris, there would be likely to be, all things being equal, a larger amount of sulphur

compounds there?—I think so. It is not only the question of ammonia but there never was any test made in Paris about the effect of ammonia kept in a sufficient proportion in gas.

Cross-examined by Mr. CRIPPS: The Paris Company are always increasing the consumption of gas in Paris, and they do as much as they can to make the most perfect gas, even if it is not asked for by the Municipality.

Mr. CRIPPS: You know that the rule here is the same as in Paris, that of entirely prohibiting the presence of any sulphuretted hydrogen in the gas; but in London, over and above that, we do not allow more than a certain quantity of the sulphur compounds to be present in the gas when it is burnt?

Witness: Yes.

Your treaty in Paris has been kept faithfully by the companies, has it not?—Yes, it has. I think during the 17 years which it has been in work there have only been three cases of action against the company for not having purified their gas sufficiently.

With reference to the same question, you stated that the coals used for the manufacture of gas in Paris are more free from sulphur than the English coals?—I did not properly say what I meant to say. There are different sorts of coal used in Paris, which are bought simply for the price; the company do not at all care about the sulphur in the coals when they buy them. Of course, they would not buy coals containing a great deal of pyrites, because the purification from the sulphuretted hydrogen would be more difficult; and if they could have pure coal, of course they would buy it. The French coals they use generally come from the Pas de Calais; they do not use much Denain, and not much Belgian coal now, because they use a great quantity of English coal and German coal, which they get from Ruhr, near Dusseldorff, and partly Sahr coal. The absolute quantity of sulphur in those coals is about the same, but the way the sulphur is contained is different. In the English coals there are more pyrites than in the French coals, and these Sahr coals have more pyrites still than the English coals; but those are not tested in an experimental way by the company. It is only a sort of science that we make a study of in the company; but when we buy coal, we do not test for sulphur at all.

Though you do not test when you buy the coal, have you not performed experiments and tested to find the quantity of sulphur in 100 cubic feet of gas from French coal?—Not generally. I only once made an experiment in Paris, and that was in 1864, and was done for a special purpose.

The late Mr. Barlow, of London, was associated with you, was he not?—He asked the Paris Company for an engineer or director of the Paris Company, and I was asked to come over to make these experiments in London, and made a special report to Mr. Barlow. Mr. Barlow made afterwards a report to the company. I found that the Hornu coal, which was used at that time in Paris, gave about 6 grains in 100 feet. It was a test made by Dr. Letheby's apparatus, but the test has been changed, and there is now a test in London that gives 40 per cent. more than the Letheby test, so that if these tests had been made by the new test, I suppose I should have found 40 per cent. more than I did then, which would have been 10 grains.

How long is it since you have taken to mix English coal for gas-making at Paris with your own coal?—It is a very long time ago. I know that when I was here in 1864 I made a contract myself with Mr. Elliot for a great quantity of English coal; and it was in use at that time, so I do not know when it began.

Can you tell us about what proportion of English coal is used to French coal now?—I am no longer engineer of the Paris Gas Company, therefore I do not know what are the coals they buy and in what proportion they buy them. I know they use different coals, but I do not know at this moment the proportion. They are using a great quantity of German coal at present, because it is very cheap.

Cross-examination continued: Another French coal I experimented upon was the Denain coal, and the quantity of sulphur compounds contained in that coal was less than 5 grains, I think, with Dr. Letheby's apparatus. I do

not know how it is now, but with that apparatus you got very irregular tests.

Mr. CRIPPS: Are you able, at the present time, to give us any information as to the quantity of grains of sulphur in 100 feet of gas made from French coal?

Witness: Nobody makes experiments in Paris about that; I do not think there is even an apparatus for testing it. I could do it by comparison. As we use about the same coal that you do, and we purify with oxide of iron, I think that we must have about the same quantity as you have.

I suppose, during the war, you did not get any German coal at all?—No; we have only had this German coal since the war.

Your shops in Paris are very much more open, are they not, and better ventilated, than ours?—Some shops are well ventilated, and others are very badly ventilated. I think the new shops in the Louvre are very badly ventilated.

The COMMITTEE: Is the result of your evidence that, supposing the Paris gas was tested for the sulphurous compounds in the same way in all respects as the London gas is tested, you have no reason to suppose that a smaller amount of sulphurous compound would be found in the Paris gas than in the London.

Witness: I think that if you use Belgian and French coals in certain proportions, you would have less sulphur than in the English coals, but as there is a mixture, perhaps we should find 15 grains. I could not say at all what would be the quantity, but I think it ought to be something between the results which I found with these French coals and the results of the English coals. Our gas is manufactured at a much higher heat, and, therefore, there would be very much difference, but it is difficult to say the exact quantity.

You could not, in fact, make a sufficiently exact comparison in order to form an opinion?—I do not think so; we do not find it at Paris of any interest to get these proportions. The quantity of sulphurous products depends not only upon the quantity of sulphur in the gas, but also upon the quantity of gas burnt in a room; and, of course, in Paris we burn a much greater quantity of gas in the same space, for pictures, and things like that, than is generally done in London. At the Paris Opera, if there is a ball there, they burn in the night 12,000 cubic mètres—that is more than 400,000 cubic feet—of gas; and if there was a great deal less, even half the sulphur in the London gas, they would have found that with the pictures there it would be a very great danger to have such a great quantity of gas burnt, but that was never so. There was no injury at all found in any place in Paris, in the theatres and in these great shops where they burn an immense quantity of gas, so that the Municipality have never asked us to test even for the quantity of sulphur.

Do you attribute the difference mainly to the difference of the coal?—I think, as a theory, it ought to be that if you have more pyrites in the coal, you have more sulphur compounds which are taken out of the pyrites.

Dr. *Charles Meymott Tidy*, examined by Mr. MICHAEL.

I am a Bachelor of Medicine, a Fellow of the Chemical Society, Professor of Chemistry and Medical Jurisprudence and Public Health at the London Hospital, and Medical Officer of Health for Islington. I was for many years the colleague, and am now the successor, of the late Dr. Letheby, in the chair of chemistry at the London Hospital. I have paid considerable attention to the gas question, and am scientifically acquainted with the manufacture and supply of gas. I have considered this matter, not only chemically, but from a medical point of view. I know of the present regulations in force as to the sulphur compounds in gas, and I certainly think that there is no need for such restriction as 15 or 20 grains per 100 cubic feet. So far as free sulphuric acid is concerned, if there is any produced, by the combustion of gas, it is in the very smallest possible quantity—infinitesimal, I may say. I am convinced of this, that, if the sulphur present in gas was oxidized to sulphuric acid, the amount of damage that would be produced would be so enormous that there could be no doubt whatever as to its presence.

Mr. MICHAEL: Going from sulphuric acid to sulphurous acid, is there

any such amount of that acid, or would there be any such amount of sulphurous acid formed, if the maximum were increased, say, to an average of 33 grains—which we understand to be the average, when oxide of iron is used as the purifier—would 33 grains, or even up to 40, cause such a formation of sulphurous acid as would be injurious to property?

Witness: I do not think it would.

I think you have samples of books and various materials in the very first inquiry which was instituted at the instance of the Athenæum Club?—Yes, I have [producing the same]; these were the original samples upon which all this inquiry was instituted. That was, I believe, the original book upon which the whole of this sulphur question arose [handing a book to the chairman], and here I have samples of the covers of books at the Athenæum which are supposed to have been injured by the sulphuric acid that was formed by the gas. I have a great many samples.

I will not trouble you to go over the whole of the samples; but do any of them furnish evidence of sulphuric acid being the agent of destruction in any individual case?—I think not; there is quite sufficient cause to account for the action which has taken place from the carbonic acid produced, and the large amount of heat evolved as the result of the combustion of gas.

Do you agree with Dr. Odling, that the disagreeable effect complained of in the burning of gas proceeds partly from the carbon products, and also from the dryness and heat of air produced by the combustion of the gas?—Yes; I think so. I can honestly say that I have done my best to find free sulphuric acid produced as the result of the combustion in a somewhat large number of gaslights in my own dining-room, and I have failed.

I think your process at the present time for detecting sulphur is rather better than that established by the late Dr. Letheby?—Yes. I would say, with respect to the history of the sulphur test—it is right I should refer to it, as it has been already mentioned, and I know something of the history of it—when that sulphur test was originally suggested by Dr. Letheby, he used large cylinders. Somewhere about the year 1860—it might have been 1859, but I believe it was 1860—those large cylinders were abandoned, because Dr. Letheby found that by the use of small cylinders he obtained a larger quantity of sulphur. It certainly was not because he obtained a smaller quantity of sulphur.

Tell me the quantity; if it were 20 grains produced by a large cylinder, what would that equal if a small cylinder were employed?—I am speaking of the cylinders of Dr. Letheby. I can scarcely give the actual proportions of those two. But with the cylinder used by the Gas Referees, which is a very much smaller one, I have made some very careful experiments, and I find that the difference is as near as possible 6 grains between Dr. Letheby's small cylinder, and the apparatus now used by the Gas Referees.

That is to say, that the apparatus which was competent to discover 20 grains, would, if now employed, discover 26 grains?—Yes; as nearly as possible.

Do you believe that there are any sulphur compounds evolved in the combustion of gas which are injurious to health; I mean after the purification by oxide of iron, even up to a maximum of 40 grains per 100 feet?—I am strongly of opinion that sulphurous acid is not injurious to health. I may say it is a matter upon which I have had occasion to make a great many experiments, and though, in the first instance, in breathing sulphurous acid there is a slight irritation produced as the result, I quite admit that directly that irritation wears away, the action of sulphurous acid is somewhat antiseptic rather than otherwise. I am quite convinced, as the result of large numbers of experiments, that sulphurous acid is not a gas which, in moderate quantity, is injurious to health.

What would you put as the quantity which would have been necessary, before even this sensation which you have described would be produced?—I do not know. I should scarcely like to fix the exact quantity. I have not a sufficiently accurate account of that, but it is nothing like the amount produced by any ordinary amount of sulphur in the gas in an ordinary room.

I will put to you an average of 33, and a maximum of 40. Would that produce it?—Oh dear, no.

Do you know, to put it generally, any results which could occur either to persons or to property, of a disadvantageous kind, by the burning of gas with 40 grains of sulphur contained in it?—I do not. I think it is right I should say, as had been said before by a witness, that if gas was offered with a small amount of sulphur at 3s. 8d., and with 40 grains at 3s. 6d., I should choose the 3s. 8d. gas; but, at the same time, having said that, I should say it with one proviso, and that is, that I did not live in the immediate neighbourhood of the gas-works where that sulphur was removed.

I am not putting it to you as a question of expense, neither do we present it as a question of expense to the committee. I am putting it to you as a question absolutely whether you know or believe that any injurious effect could be produced, by the burning of that gas, either upon health or property?—No, I do not.

Having devoted attention to the matter, do you agree with the other witnesses, that where oxide of iron is employed at the works, and a small quantity of lime is used to take out the carbonic acid, the maximum would be 40 grains, and the average might be taken as 33 grains of sulphur in 100 cubic feet?—It is somewhere from 33 to 35.

Examination continued: I do not know any other mode which can be adopted, if the sulphur compounds, other than sulphuretted hydrogen, are to be taken out, than the adoption of lime as the purifier; and I do not believe that it can be so employed as not to create a nuisance. Sulphuretted hydrogen, even in small quantities, cannot be inhaled without producing bad effects upon health. I can only say that, in the course of my lectures on toxicology at the hospital—this was before the Vivisection Act came into force—I was always accustomed to show the effects of an atmosphere containing one per cent. of sulphuretted hydrogen by putting a sparrow into it, and the sparrow dropped down dead immediately. I showed it at one part in a hundred; but I could have reduced it very much indeed. There have been a large series of experiments made upon the action of sulphuretted hydrogen; the earlier experiments were made by Parron de Chatillet, then Barker, and then Dr. Letheby; and I believe they all agreed very nearly in one fact, that small birds died after a time when there was one part of sulphuretted hydrogen in, according to Parron de Chatillet, 1500 of air; according to Barker, 1800 of air; and according to Dr. Letheby, 2000—that one part in 2000 would be fatal to birds; and then, when we come to dogs, it has been found that one part in 200 will destroy the life of a dog.

Mr. MICHAEL: Putting it not as a matter of destroying life, but as to injurious effects upon health, do you believe that a comparatively small quantity of sulphuretted hydrogen in atmospheric air, employed as the ordinary medium of breathing, will produce injurious effects to a person in an ordinary state of health?—Most assuredly.

Such an amount as would be likely to arise after the process of emptying the purifiers?—I should think so, most assuredly.

Have you seen instances of injury to health from sulphuretted hydrogen?—I have, in the case of sewer gases, very frequently.

Is there any particular difference between the sulphuretted hydrogen evolved in a sewer or from decomposing organic matter, and the sulphuretted hydrogen given off from the opening of the lime purifiers?—No; I am convinced of this, that the active agent in the case of sewers is sulphuretted hydrogen, and I think that is agreed on all hands.

Generally, do you consider—according to the evidence we have had before us, it is inevitable that some amount of nuisance must be created by the use of lime as a purifier—there is any corresponding advantage in the abstraction of the 10 or 15 grains of sulphur which the lime would take out of the gas?—No; my own feeling in the matter is, that I should be very glad to have no sulphur at all, but the objections arising from the process of the removal of the sulphur seem to me to be infinitely greater than any harm it can possibly do by remaining in the gas. As a matter of fact, putting it in another way, the difference between 20 and 35 grains of sulphur in the gas really amounts to this: Say the difference between 20 and 35

is 15 grains, and say there are two burners in a room, burning three cubic feet each an hour for four hours—that would be 24 feet. Every sulphur match has in it about one grain of sulphur, and the whole discussion between 20 and 35 grains is really as to whether three sulphur matches may be lighted during the evening.

The COMMITTEE: Do you mean to say that the ignition of three sulphur matches in a room would produce as much sulphuric acid eventually as the combustion of the amount of gas you have mentioned?

Witness: Yes; taking the actual facts. It is not an opinion in any way. But even that is not an accurate comparison, because in the case of gas there is some ammonia present, which neutralizes any fumes that are produced, whilst in the case of sulphur matches there is no ammonia present; that is the actual fact of the case.

We did not hear from the French witness that the ammonia neutralized the sulphurous compounds after combustion, but it was only before combustion that they were held in suspense, as it were. On the contrary, the witness said positively it would not have any effect after combustion. The question you were asked was this: Do you mean to say that burning an ordinary sulphur match, or four of them, would produce as much of the injurious sulphurous compounds as the burning of two gas lights?—Yes. I have made a large number of experiments as to the amount of sulphur on those matches, and I can say that as a rule it is over one grain, but ordinarily one grain may be taken as a very low average.

Can you say that on striking a lucifer match the fumes it gives off contain a grain of sulphur, which would be spread through the room in the same way as the sulphurous compounds come from gas?—Yes; wherever sulphur is found, it is no matter whether it is in combination or not, the facts are the same.

Mr. MICHAEL: The rule is, in a sulphuric acid combination, or in any other combination, that when sulphur combines with oxygen, it will combine in definite proportions, whether you have it in the solid form, or in the vapour of gas?

Witness: Yes.

You have given a homely illustration. If we could collect the products of combustion in a bell-glass we should have precisely the same, whether four matches were burnt, or we had the same quantity in gas; and therefore one thing would be that you burn the four matches altogether, and in the other case you have four hours during which the whole quantity is diffused?—Yes.

Is there any other difference?—No.

Looking at the triviality of such a quantity, and the possible effects of it, is it worth while to run the risk of all this complicated process, and the nuisance which is almost inevitable from its use, to get rid of such a thing?—I should prefer not to have four sulphur matches lighted; but, knowing the injury that results from the process of taking away the sulphur from gas, I think it is infinitely worse than the presence of the sulphur.

You know of no other means, neither has any chemist suggested any other means, which practically are effective, without the use of lime, for getting rid of the sulphur compounds?—I do not know of any.

Cross-examined by Mr. O'HARA: I have not seen the process of purification in operation at the works, because the purifiers have been shut on my visits to the works. I am not a practical gas-maker, and what I say is theoretical; but, of course, it is regarding the matter from a purely scientific point of view. I say that in a sulphur match there is, on an average, one grain of sulphur, and when you burn that match, the sulphur becomes sulphurous acid as the result of burning it. The amount of sulphurous acid produced is actually fixed and definite.

Mr. O'HARA: Are you referring to some antiquated cast-off kind of match?

Witness: I am referring to a sulphur match. I am not saying whether it is old or new. I am not referring to Messrs. Bryant and May's matches, because they use paraffin.

Did you ever weigh the sulphur on one of these old matches?—Yes; I have, upon more than one occasion, very accurately weighed the amount

of sulphur. It became a great question once as to how far that sulphur could be kept down, and upon that occasion I weighed the wood very carefully. It was then dipped in sulphur, and I took the weight after, in order to determine the amount of sulphur present.

You said the ammonia in the gas neutralizes a certain quantity of sulphur in the gas?—It is not the ammonia in the gas that neutralizes it, but there is ammonia in the air neutralizing it.

Then with the two ammonias combined?—I cannot say at all.

Can you go anywhere near it?—No; I think that is a matter which varies so much that it would be impossible to give you an opinion.

You agree with Mr. Vernon Harcourt, that if you could get gas at 3s. 6d. per 1000, in which there was an increase of sulphur compounds, and if you could get gas for 3s. 8d. without the sulphur compounds, you would prefer to pay the 3s. 8d.?—I should.

Let me take you from a question of chemistry to a question of honesty. Supposing you agreed to give a man gas at 3s. 8d., free from sulphur compounds, and it cost you 2d. to purify it, and then you proposed to give him gas with sulphur compounds, and not alter his price—would you think that fair?—No. I think that this question of the purification of gas ought not to be a money question. If I could see my way to suggest that the gas company should keep their sulphur down to 10 grains, even if it cost them an enormous sum, I do not think that I would venture to give evidence here to-day upon this subject. I feel very strongly that, if the sulphur can be removed, it is not a question of expense at all that ought to influence it; and I will even go further on your side by stating that I do not quite advocate making the sulphur an open question.

Supposing—we will assume a more violent supposition—supposing this committee were to relax the test for the impurity of sulphur, would you think that it would be fair that they should diminish the price as well?—That really is a question I must not enter into; I do not know the question of price. Regarding the consumer on the one hand, and the manufacturer on the other, I think that the limit of sulphur—it is only my opinion, of course—might be fixed at 35 grains, and I hold that view very strongly. I also hope that even that amount will not be permanent, because I trust that as science progresses means will be shown by which the sulphur can be removed. I should be very glad to have no sulphur in the gas at all; but, as science is at present, I feel that Parliament might very fairly, in the interests of the public, and in the interests of the gas companies, reduce that sulphur to 35 grains.

But, beyond that, you think it is very dangerous?—No; I did not say it was very dangerous. I said I desired to reduce any impurity—and I admit sulphur to be an impurity—to such a quantity as that it should be removed without causing in any way a nuisance to the public.

The COMMITTEE: Which do you mean, an average of 35 grains, or a maximum?

Witness: I mean that a matter of that kind should be taken on an average of three days—that if the sulphur was more than 35 grains on an average of three days, the gas company ought to have to pay for that sulphur being in.

Mr. O'HARA: The present penalties (I do not know whether you are aware of this) are only levied on the average of three days?

Witness: I believe that is the case, and I think that is very fair. Of course, you are always obliged to trust a certain amount in an average of three days—that is to say, even taking 20 grains, they may have 40 on one day, and none the next, and, therefore, your average of two days would still be 20 grains.

You know, of course, you could fix a small maximum, such as 20 grains, and prevent this excessive average?—Yes, but the difficulty of that is the use of this lime process of purifying, where the undoubted existence of a nuisance is so clear.

Supposing it were demonstrated to your satisfaction that this process of purification could be carried on without a nuisance, would you then be for 20 grains always as the smallest amount of sulphur?—I go in for none at all—that is to say, if the sulphur could be reduced to none at all, I should be very glad to have it; but I am convinced, in the present state of

science, that there are no means whatever, without producing a nuisance of its being reduced to that.

Have you ever made any experiments as to purifying in gas-works?—I have tried laboratory experiments, but only those by the Bowditch system. I have heard from others of their trials, and I know very well the smell of a purifier when it is opened, but I am obliged to accept in some degree other people's tests for these matters.

To make any experiment valuable, ought it, in your opinion, to be derived from practical experience in gas-works?—I consider that you must try every experiment on a large scale before you can form a proper and true estimate of the results of that experiment.

You yourself have not tried them on a large scale?—No, I have not.

The COMMITTEE: With regard to your evidence as to the injury caused by the presence of this sulphur in the gas, do you think there is any injury except the irritation of the throat?

Witness: No. I can give you an illustration on a large scale of that. One of the first cases I happened to be engaged in professionally was the atmosphere of the Underground Railway, and I made, in conjunction with Dr. Letheby, in 1861, I think, a very large number of experiments on that question of sulphur, and the result of our experiments was, that, though undoubtedly there was a slight irritation set up at first, that irritation never had any injurious effect. I will tell you another thing with respect to that sulphur. At the time of the inquiry all the railway men on the Underground Railway subscribed to a club, and they had applied to that club to have the weekly sum they paid in reduced, because so very few cases of illness occurred among the men. It is perfectly wonderful the amount of sulphurous acid you may have in the atmospere. As regards the injury to books, furniture, and so on, I am quite convinced that the excessive heat and the relative dryness of the air which we have heard so much about, is sufficient to cause most of the injury, or nearly all. There may be, in my opinion, a little acid sulphate of ammonia formed.

You say it is of enormous importance that ultimately these sulphur compounds should be entirely got rid of. Is there any substantial injury that you consider is done to any living person or to any object around us except the irritation to the throat which you have spoken of?—No, I am quite convinced there is not—not by such a quantity as the difference between 20 and 35 or 40 grains.

Mr. MICHAEL said that was the case on behalf of the promoters.

WEDNESDAY, MAY 16.

The CHAIRMAN said as the case of the promoters was closed, he thought it might simplify and shorten the proceedings if he stated what the view of the committee was at that time. The promoters by their Bill asked that the 30th and 51st sections of The Gaslight and Coke Company's Act (their last Act) should be repealed; that was to say, the section which established the authority of the Gas Referees for the purpose of controlling the company, and in order to obtain a certain degree of purity in the gas. It was objected by the Metropolitan Board of Works, by the 6th clause of their petition, "That, as your petitioners are advised, it is of the utmost importance that a proper limitation should be placed upon the amount of impurity in gas, such impurity being highly detrimental to the sanitary condition of the Metropolis, whereas, if the Bill is passed into law, it will be in the absolute discretion of the company to supply gas with any amount of impurity, either of sulphur and ammonia and of the compounds thereof." The Corporation of London, also, in their petition, said that if those clauses should be repealed, "they would be left to the mercy of the said company to supply them with gas charged with any amount of impurity they pleased; and it has undoubtedly been proved, before more than one committee of your honourable House, that the impurity contained in the gas is most injurious and detrimental to health, and causes vast injury to all descriptions of goods and merchandise." If the case rested there, the committee thought that no other course would be open to them than to declare the preamble not proved. But, a suggestion

had been thrown out by Mr. Pope, to the effect that if the committee came to the conclusion that there ought to be some restriction, then justice would be done between the company and the public, by restricting the power of the Referees to the maintenance of a test, the minimum of which should be of such an amount as, in the words of the Act of Parliament, would render it possible to maintain a reasonable amount of purity. The committee were desirous, if they could, so arrange it to the satisfaction of both sides, to adopt Mr. Pope's suggestion in a modified form, but, of course, they were quite ready to hear what might be said by the petitioners if they should not agree with that suggestion. The terms the committee were disposed to offer to the promoters of the Bill were that the limit of impurity as to sulphurous compounds (as regards the other impurities they did not propose to make any change at all) should be fixed, experimentally, at all events, at such a limit as would make it possible to avoid what was called the lime process of purification. At the same time they would require that the line so fixed in the Bill should not be reduced, unless by direct order from the Board of Trade.

Sir E. BECKETT: When you say that it should not be reduced, does that mean, supposing we start with 40 grains, it should not be reduced below 40 grains.

The CHAIRMAN: Yes; that is to say, that the Gas Referees, in the exercise of the discretion vested in them by the 30th section, shall not reduce the limit below 40 or 35 grains, or whatever we arrive at, as the lowest limit which can be attained without the use of the lime process, unless by direct order from the Board of Trade.

Sir E. BECKETT: To put it in a cognate form, it comes pretty much to this: Supposing we agree that 40 grains is the limit that can be reached without lime, then you would take 40 grains, assuming it to be so—as the maximum, in short.

The CHAIRMAN: As the maximum.

Sir E. BECKETT: And also as the minimum, unless the Board of Trade otherwise order?

The CHAIRMAN: Yes.

Sir E. BECKETT: That is a matter that requires a little consideration.

The CHAIRMAN: I am not sure that you understand about the minimum. What we mean is that the average that would be obtained in that way, as I understand the evidence, would be an average of about 33 grains.

Sir E. BECKETT: The average seems rather doubtful in this case.

The CHAIRMAN: Therefore we say the maximum. We say that the Gas Referees are not to reduce it, and in that sense you are quite right, it would be the minimum. The Referees ought not to oblige the company to keep the impurity arising from sulphurous compounds below a limit of 40 grains in 100 cubic feet.

Sir E. BECKETT: As you have just now mentioned 33 grains as an average, would you put 33 grains at once into the Bill, do you mean?

The CHAIRMAN: No, because that I believe is not so convenient a method of doing it. There is also another question upon which we should like to hear what you have to say—namely, whether we might not fix the maximum at 35 grains, and give an average of a week instead of three days. I likewise think there is another condition we should have to impose upon the company if they are disposed to agree to these terms, and that is that they should, from time to time, make such reasonable experiments as the Board of Trade might require.

Mr. RICHARDS: Most certainly; we have it as much at heart as anybody can have.

The CHAIRMAN said there was another question which would afterwards have to be considered. Mr. Pope had put the case as between the company and the public, but the committee were not disposed to make any concession to the company in their interest alone, under the circumstances of the case, they having last year obtained their Act, and having agreed to the principle upon which that impurity was at present restricted. The committee did not think that the company, as such, had any *locus standi* to complain at all, but they certainly had made a case on behalf of a certain portion of the public, and the question was one between the consuming portion of the public and that portion who were suffering

injuriously from the nuisance arising out of the purifying process at present adopted; and, therefore, after they have agreed upon that part of the case, they would be glad to hear anything that might be said by those representing the public—the Corporation and the Metropolitan Board of Works—as to the financial question; that was to say, as to whether any terms should be imposed upon the company with reference to the price at which the gas should be sold to the public. It was quite plain that if no such provision were made, there would be a very considerable economy for the company, and that would represent a considerable advantage financially, as well as in convenience and other ways. He (the chairman) was not quite sure that he was right, but he thought, as far as he understood the case, that that advantage would be only partly shared by the public under the system of the sliding scale; the alteration of the system at present adopted would go to reduce the cost of the gas, and part of it would go into the pockets of the company. If those views were accepted, the committee would require further evidence on the question, whether the quantity should be 40 grains, taking the average ascertained on three days, or 35 grains on the average of a week.

The parties retired to consult, and, upon their return.

Sir E. BECKETT said: I am sorry we cannot save any time. We think that we ought to go on, and also that, with a view to proceedings hereafter, it is not expedient to withdraw any of the evidence.

Mr. *George Anderson*, examined by Sir E. BECKETT.

I have been engaged for about thirty years in managing gas-works, and am lessee of several now. I have considered the subject of purification, and have read several papers upon it, one of which obtained the premium from the British Association. I manage gas-works at Dover, Waterford, and three or four other towns that I need not name. I am engineer to the Cork Gas-Works, and to a number of other gas-works. In no case am I under any restrictions as to sulphur, excepting sulphuretted hydrogen. Although not under restrictions, I have managed to get my sulphur down to about 15 grains. I have always considered, as a lessee, that it was my interest to have as much gas consumed as possible; and as I thought that the purer the gas the more would be burned, I have paid a great deal of attention to the subject, and I have my gas as pure and salubrious as possible for that reason. I use precisely the same coal that is used in London—Ravensworth Pelaw and Pelaw Main. I do not know anything about the Paris gas, or the coals they use there. I have used the same tests as they do in London. I had my offices fitted first with Letheby's test; afterwards with the Referees test; and more recently, being a more facile arrangement, I have used Mr. Harcourt's test. The result I have obtained is from 10 to 16 or 18 grains.

Sir E. BECKETT: Of course the important question comes, what means do you use for arriving at those results?

Witness: In that sense I use means a little different from what they do in London. I am very particular, first, in the cooling of the gas; next, in the washing of it; and next, in the scrubbing of it, so as to remove a very large proportion of the impurities before the gas enters the purifier at all. My objection, and I have stated it before, is to the fact of finding so much sulphur in the gas in London, which is due to the previous processes. They have not, in my opinion, been so scientifically attended to as I think they should be. More stress is laid upon the purifiers, and consequently there are more impurities to be removed by them, and more difficulty in doing it. I use both lime and oxide. I have not had any complaints of nuisance for several years. About eight years ago I had one at Dover; but then it was because our works were incomplete. We had only two purifiers there at that time, and we could not work upon the system as we ought to do, and we certainly had some nuisance; but since we have completed our works we have not had any complaints for many years. I have heard of some people complaining at Cork, but nothing ever came of it; there was never any action, or anything of that sort.

You are confident, are you not, that, by taking means that are known to practical people it is possible to reduce the quantity of sulphur below 20 grains without incurring any nuisance?—Yes, with improved apparatus.

Is it very expensive, that is another thing to ask?—No, it is not any more expensive than the apparatus now employed, but they require more of it. I would even go beyond that, and say that if investigation upon this subject is not opposed by legislation which will not require purity, my opinion is that we shall go on making gas, and arrive at even lower than that—perhaps to eight or ten grains.

Mr. M'Minn said that science was never to advance in that direction. Do you think so?—I think the very opposite of that; I think it is advancing very rapidly.

You think that if people are kept under a little decent pressure, they will soon find means of reducing the sulphur to 10 grains?—I think it would be to the interest of the companies to do so, because the purer they make their gas the more of it will be burned, especially in a place where a good deal is burned in the daytime.

You seem to think that there is something in the sulphur after all; that it is not a desirable thing?—I do not go so far as some people talk, as to its being injurious to health; but I believe it is injurious in this way, that it is unpleasant, and I am not quite sure that the products that come off when the gas is burnt are merely sulphurous acid. If it was sulphurous acid, I do not think it would be so unpleasant as it is; but I have had personal experience of headaches when I have been burning gas in my office in London, and I do not think that sulphurous acid alone would have done it.

Do you find the same result—headache, or whatever it may be—at the places where you have your own gas?—I have not had the same means of trying it, and therefore I should not like to make that comparison.

Examination continued: My plan is to keep the gas in contact with ammoniacal liquor, instead of draining off the liquor from the gas, as is often the case. The ammoniacal liquor has an alkaline action, and it absorbs a large quantity of carbonic acid from the foul gas. I have done this for a number of years without really thoroughly understanding the chemical reason why I have got the benefit; but Mr. Patterson, about three or four years ago, discovered that while the carbonic acid remained in the gas, it was difficult to cause it to deliver up the bisulphide of carbon that causes the mischief. If, however, the carbonic acid was removed from the gas, and brought in contact with an alkali, there being less acid to neutralize the alkali, the acid sulphide of carbon would be attacked by the alkali—lime—which would therefore remove it. It so happened that my process was just following exactly in this line. I have always taken out as much carbonic acid as I could before bringing the gas to the purifiers at all. The consequence is, that all the gas engineers have expressed to me their wonder how I purified my gas with so little lime. I have stated the quantity of lime I use, and in comparing it with their cases, they have always said that I did not use above half the lime they did, and they did not understand it. I have explained to them that it was because I did not give the lime so much to do as they gave it. I do not know that I need go any further. I should also say that the doing of this renders the lime almost innocuous. If you thoroughly carbonate the lime—that is, allow the foul gas to go through it for a long period of time—you send the sulphur out of the lime, and you leave the lime a hard substance, like a porous stone, which has really no smell; you may put your nose over a purifier, and scarcely smell it. I have a piece of lime here [producing a sample], taken out of the last purifier we cleared, which was on Tuesday or Wednesday.

Sir E. Beckett: With regard to taking the lime away from the works, do you think that they manage that rightly in these London works?

Witness: Granting that they have a smell, I think they use a considerable amount of caution; but I consider they might do it even in a better way than they do. In the first place I must state, from what I have read recently, that when the lime is being taken out it is in a dusty state, and the dust of the lime blows about and causes the smell. I think that is exceedingly likely, but I contend that, by the proper use of lime, when it is taken out of the purifiers it should never be in a dusty state. You may pass foul gas through dry lime, and it will come out foul gas; but put some water in that lime, and then it is impossible for the gas to

come out foul. You want the water to have contact, and then the lime comes out in a lump, and the pieces produced are those that come out.

The COMMITTEE: Those are dusty?

Witness: That is because they have been rubbed together in coming here. My lime is in lumps, and it has to be taken out with a pick. Another mode that I would adopt—and which I do not know that they have done—would be, before opening a purifier, to leave it, say for 24 hours, to cool, because when the stuff has cooled it has much less chance of delivering noxious gases than when it is warm, which it is when the purifier is shut off from making gas. I would also inject steam into the purifier after it was shut off, for the purpose of causing the lime to collapse and shut up the pores. When the lime is porous the oxygen of the atmosphere gets in through it, and delivers any smell that can be got from it. If you were to keep it in a state of pulp, partially pulped, it closes up the pores, and you might remove it, even if it had noxious ingredients in it, with much less smell than in a state of dust. Again, I should have a thoroughly closed barge that could be locked up—covered over with simply man-hole doors, the same as the hold of a vessel, so as to leave the chance of the air acting upon it as little as possible.

Can the sulphur be got out again, and the lime utilized?—If it were absolutely necessary that you must remove the sulphur compounds, and must not take away the lime, even then I say that I could take the sulphur out of the lime in the works, and use the lime over and over again for purifying the gas, the same as they take the sulphur out of the oxide and use it over and over again, and get the sulphur as a saleable article to sulphuric acid makers.

Have you ever done that?—I have not done it with the lime, but I have with oxide of iron. I mean to say that I have taken the whole of the sulphur from the oxide of iron which the companies now sell as useless, and I have used the oxide of iron for years and years without selling it, or taking it off the works at all.

Why have you not done it with the lime?—Because the lime in our case was cheap, and we did not consider it worth while.

They talk so much here about their being encumbered with a great quantity of lime—if they were so encumbered with it they might treat it in that way?—Yes, they might do so, and there are some people who do do it, I believe. It makes the lime caustic again—makes it ready for putting into the purifiers. It takes away the carbonic acid and all the impurities.

Cross-examined by Mr. RICHARDS: My gas is not tested for sulphur compounds by any public officer, and the results I arrived at were merely for my own edification. My works at Dover are small as compared with London, but they are larger than many others; you must have things in proportion. I have never taken out a patent for my scheme of dealing with the lime. Mr. Patterson took out a patent for his discovery, but the novelty of it was disputed in Chancery, and he had one decision for him and one against him, but I have heard he is now applying to have another in his favour if he can get it, as he is going to appeal to the House of Lords. His process was disputed upon the ground of novelty, not of utility; for since the companies have used it they have been able to reduce the sulphur compounds to 8 or 10 grains. I was examined before the Revision Commissioners in 1874, when the company applied for an increase of price.

Mr. RICHARDS: Did Dr. Odling, who was one of the commissioners, ask you this:

If all your lime coming out consists mainly of carbonate, I want to know in what form you take out your sulphur from the gas. If none goes into the purifying material, where does it go to?—Most in the scrubbers and washers.

I think you said your lime was sulphuretted to some extent?—Yes.

But not when you take it out?—Not when I take it out.

Sulphur is not a thing you can squeeze into nothing; you cannot squeeze anything into nothing. I want to know, in purifying gas in that way, what is the form in which you take the sulphur out?—I should very much like, if you could, during the bathing season, to come down and visit it for yourself; the fact is, as I state, that we work our purifiers a long time.

You drive your sulphur from one purifier into another; you never take it out?—That

is the something that takes place. At Beckton they have oxide of iron purifiers for the purpose of taking out the sulphuretted hydrogen at the last. I take out the sulphuretted hydrogen without doing so.

I cannot understand your taking out nothing but carbonate of lime, and yet removing the sulphur of the gas?—The same thing has gone through my mind that it will get by-and-by into that condition that it will be choke full, but it is not so; the gas is tested, and it would not do to have sulphuretted hydrogen in it.

You do not seem to me to give any satisfactory answer to Dr. Odling's question of what becomes of the sulphur?

Witness: As I have heard you read it, it appears that Dr. Odling was arguing from premises which I do not admit—namely, that I took the lime out pure carbonate.

I only ask you what Dr. Odling asked you, and that is, where is the sulphur? If it goes through the lime, where is the sulphur? You say it is taken out of the gas; where is it?—It exists in the lime in a state in which it does not give off so much smell, in consequence of the large quantity of carbonic acid in the lime.

Have you analyzed that lime to ascertain whether sulphur is in it?—I have not; but I have given samples of it to chemists, and I dare say it is possible that during this inquiry you may have an analysis.

You yourself are no chemist, I presume. You set yourself up as a gas engineer?—I do not profess to be a chemist, but I know more about the purification of gas than some chemists do.

Cross-examination continued: At Dover we have six purifiers, two filled with lime and four with oxide, and the gas is passed through the lime first, and then through the oxide. Our old works were situated under the cliffs, but they have been abolished, and new works erected a little way outside the town, about 40 feet above the lowest part of the town. The old works were complained of by the people in Marine Parade, but it was more on account of the smoke than anything else, and they were never serious. In those old works we had not the means of purification which we have in the new ones. We worked with the old purifiers, and the arrangements of 20 or 30 years before that; and the reason for removing, I may say, was twofold—one was that the works were in the town, and another was because the place was altogether too cramped—in fact, we had no room to do anything.

Mr. RICHARDS: You say it is not difficult to deal with lime with proper apparatus. Is that an apparatus that you have invented?

Witness: No, it is not; but I would invent it if I had this thing to do.

You mean to say that if this problem was submitted to you, you could deal with it very easily?—I do not doubt it at all.

Have you got what you describe as proper apparatus in action anywhere?—I have not required it.

You have not had any practical experience of this proper apparatus?—Yes; I have had experience of a proper apparatus, but not for carrying out the necessity that exists here of taking away these smells. I should like to give my reason for this. Taking that little box represented there as being the thing to put some oxide of iron into, and the exhauster for drawing air up from the large purifier into it and through it, I think any person would expect to get a smell under such circumstances; that box should be six times as large as it is. The gas coming from the purifier through that very small thing would be passed through it at a very considerable velocity, and I believe that it would come through only partially purified. There would be some impurities that would go through, but if that vessel had been six times as large as it is, and the gas were allowed to go very slowly through the material, you would have a far better combination, and you might not have any smell from e surface of the vessel.

You know that the operation proved a failure. Have you ever tried a large vessel?—I have tried this, which is the same thing.

Will you answer the question, and then explain afterwards?—In the first place, I say no; then I give this explanation. When you have a small purifier in proportion to the gas made, you require double or treble the amount of material for doing the same amount of work. If you enlarge your purifying surface and the gas goes through slowly, so

that the products of the gas and the lime come slower in contact and hug each other more slowly, you get a combination to take place which does not take place if the gas is rushing past the material. If that is the case with your large purifier, what is the small purifier but purifying the gas a second time?

You would, under the circumstances, not multiply?—Not multiply, but magnify. Magnifying is better than multiplying, because if you multiply you must send through each vessel in succession, and at the same velocity; but if you magnify you get a lower rate of speed from what you otherwise would do.

What are the limitations as to sulphuretted hydrogen and sulphur compounds in the Dover Act of 1860. Is it not that you shall be free, as far as possible, from sulphuretted hydrogen and other compounds deteriorating its purity?—It is in those exact words; but I may state that we have an inspector of gas who is daily testing the gas, both for ammonia and for sulphuretted hydrogen, and really I should have no objection if he were to test it for sulphur compounds.

Re-examined by Sir E. BECKETT: It is not requisite at large works to have any different mode of purifying to that in use in small ones; only larger apparatus. What answers for 400,000 or 500,000 feet will answer for 17,000,000 feet if of larger dimensions.

Mr. *Clarence William Raymond*, examined by Sir E. BECKETT.

I am Inspector of Chemical Factories to the Poplar District Board, and know generally the process by which the gas at the Bow Common works (which are in my district) is purified. It is by lime and oxide. At the present time that process does not cause any nuisance. I have often been present when the purifiers have been opened, and have seen the lime turned out. When the lime purifier is turned off, the lids are raised, and the air is drawn through from 18 to 24 hours before the lid of the purifier is lifted off—that is passed through the oxide of iron, and anything that escapes from the oxide of iron passes away into the flue. We experience no nuisance from it now, neither have we had any complaints with reference to the works since October, 1875; before that we used to have a great number of complaints. Acetate of lead paper is not at the present time blackened by the effluvium. The lime is employed twice over. There used formerly to be a great nuisance, especially through the emptying of the purifiers, and after the lime was lying there; but the company were threatened with an action for nuisance, and since they adopted the mode they now employ there have been no complaints of nuisance. The gas-works are surrounded by houses, some within 30 yards. As to the waste lime, the farmers cart it away; in short, I am perfectly satisfied with the present condition of things.

Cross-examined by Mr. RICHARDS: The Bow Common station is one of The Gaslight and Coke Company's works.

Mr. RICHARDS: Do you think it intelligible that they should conduct their works in this way in one place, and neglect the best course of proceeding at another station?

Witness: I speak as I find those works; I cannot say what they carry out at others.

The particular neighbourhood in which the Bow works are situate is not what you would call a very savoury neighbourhood?—No; at times it is rather bad.

A stink or two, more or less, does not make much difference?—No.

You speak of houses near. What sort of houses are they—factories or chemical works?—No; dwellings of from six to seven rooms, I suppose.

Sir E. BECKETT said before he called the next witness, he would ask the committee whether they thought it desirable to have more evidence upon the question of the injuriousness of the sulphur itself. He rather understood they wanted to have evidence upon the question of getting rid of the nuisance of the lime.

The CHAIRMAN said the view the committee took was that, of course, it would be a great advantage, if it were possible, to get rid of the sulphurous compounds altogether; but that as a balance of convenience in reference to the increased amount of sulphur, as between 20 grains

and 40 grains in the 100 cubic feet, and the nuisance of the lime process of purification, they were disposed to have the experiment tried. The clause he had suggested would enable the Board of Trade at any time, in the first place, to have such an experiment as they had just heard of tried at the works of the company in London; and in the second place, if they thought a case was made out for such an alteration, to reduce the sulphur maximum.

Sir E. BECKETT said he did not think it necessary to argue that point at present.

Mr. *George William Wigner*, examined by Sir E. BECKETT.

I am an analytical and consulting chemist, and have been making some experiments showing the result of gas burning in London with an average amount of ventilation. I have here a table which shows these results:—

Experiments with Ordinary Coal Gas burnt through Argand, Fishtail, and Bat's-wing Burners under ordinary circumstances, in a Room with a Fair Average Amount of Ventilation.

Mark	B	C	F	G	H	J	M	N	P	T
No. of Experiment	1	2	3	4	5	6	7	8	9	10
Gas consumed	150	140	300	300	350	250	150	110	34	42
Number of Burners going	3	3	8	8	8	6	6	3	1	2
Sulphur in gas per 100 cubic feet	10·30	16·30	9·10	9·00	14·68	18·51	10·50	10·30	13·20	9·60
Equal to sulphuric acid	47·32	68·46	83·73	82·71	157·35	141·71	48·23	34·70	13·74	12·34
Amount recovered as sulphurous acid	—	—	—	—	—	—	—	—	—	—
Amount recovered as sulphuric acid	23·27	40·61	35·30	33·80	35·86	32·48	30·10	20·95	6·03	5·57
Per centage of total sulphur recovered as sulphuric acid	49·10	58·66	42·16	46·91	22·80	22·00	62·40	60·40	44·00	45·10
Cubic feet of air drawn out of room per foot of gas burnt	103·80	125·90	52·50	56·90	55·40	72·60	135·00	166·00	311·00	150·00
Per centage of total sulphur recovered as free sulphuric acid	26·70	38·10	26·90	25·10	13·50	12·70	45·70	46·70	12·70	23·40

To make that table intelligible, I should say that these experiments differ from the experiments of Dr. Odling and Dr. Stevenson, inasmuch as, instead of drawing a small sample of air from the centre of the room and testing that, I have ventilated the experimental room in which these experiments have been carried on, through a ventilator of fair average size—that is 6 inches square—and have actually tested the whole of the air escaping from the room during the whole time the gas was burning. In the worst experiment out of ten which I made, I had recovered 22 per cent. of the sulphur present in the gas in the form of sulphuric acid; and in the best experiment I collected 62 per cent. in the form of sulphuric acid. The experiments differed slightly in the conditions under which they were carried on, mainly in the number of burners which were used. Instead of allowing the ventilation of the room to take place through an ordinary Arnott ventilator, which would be at the top of the fireplace, close to the ceiling, I drew the whole of the escaping air from the room by means of a steam exhauster, worked by a steam boiler, through a series of glass tubes, made of plate glass, and of an area of about 6 inches, and in those glass tubes I suspended various articles on which I wanted to test the effects of the product. Those tubes would make a total length of about 15 or 16 inches, so that the air, or, rather, the products of combustion, in the passage through the tubes became cold; therefore the articles which I exposed so as to test the character of the products were not exposed to hot air. They were not exposed even to the temperature which would be at the ceiling of the

room; but the temperature very rarely exceeded 80°, and sometimes was only 65°. I then passed those products of combustion further through a series of cylinders of about 18 inches or 1 foot 9 inches long, each full of glass marbles and bubbles—those glass marbles and bubbles being kept wet with water, or with different solutions, so as to absorb the acid, and so on, which might be given off—and again I passed them into a second long glass tube, so that any further deposit might take place from them, and then finally they escaped through the steam exhauster into the chimney. Therefore, I first of all cooled the products of combustion by letting them pass through the tube; secondly, I passed them over certain materials; thirdly, absorbed, as much as I could, the sulphuric or sulphurous acid produced; fourthly, I allowed them to deposit any moisture carried away; and fifthly, passed them up into the chimney; and the net results of all these experiments is—and I have carried them on altogether for 18 entire days—that during those 18 entire days there has not been drawn through this ventilator, as I call it, for want of a better name, at the top of the room, enough sulphurous acid to discolour in the slightest degree a piece of iodic acid and starch paper. In other words, I am quite justified in saying that there has been no sensible or appreciable amount of sulphurous acid produced. On the other hand, taking the sulphuric acid, I have recovered different per centages, varying from 22 to 62 per cent. of the sulphur present in the gas in the form of sulphuric acid. Thus, on the particular day on which I got the best results, I burnt 150 cubic feet of gas. Six burners were used, of which two were Argands, two were bat's-wings of different kinds, and two were fishtails, and the gas contained 10·50 grains of sulphur per 100 cubic feet, which would be equivalent to 48·23 grains of sulphuric acid. I actually recovered from it, in the form of sulphuric acid, 30·10 grains, which is 62 per cent. of sulphur present; and of this 62 per cent., 46 per cent. was recovered as free acid; that is, sulphuric acid. I have here a sample of a bit of iodic and starch paper, which I exposed in this apparatus to the products of combustion of some 50 feet of gas per hour for 20 hours—that is 1000 feet of gas [producing the same]. Sulphurous acid will discolour that paper, and will turn it blue directly; and here is the other [producing another sample], which is obtained by combustion, in an open vessel, of only 5 grains of bisulphide of carbon, in a room of a similar size. I observed Dr. Tidy's statement about the sulphur matches yesterday, and have made some experiments upon that subject since. I have no doubt whatever that Dr. Tidy's evidence was perfectly correct as far as regarded sulphur matches; but they are things which are perfectly unused in London now.

The CHAIRMAN: We need not go any further into this business.

Sir E. BECKETT said he did not wish to do so, only Dr. Tidy seemed to think it of consequence.

Cross-examined by Mr. RICHARDS: I am public analyst for three districts, Gas Examiner of Greenwich, a Fellow of the Chemical Society, and a Fellow of the Society of Public Analysts, but am not connected with any hospital.

Mr. RICHARDS: If sulphuric acid is present in the quantities you describe, would you not expect to find it depositing itself in the lower parts of the room, rather than rising to the ventilator?

Witness: To a very small extent. During those experiments I placed at the ceiling of my room, which is about 10 feet 6 inches high, a small circular plate of ground glass, whitewashed each morning with pure precipitated lime and distilled water, and each evening this plate was taken down, and the whitewash on it carefully scraped off and tested, in order to find the amount of carbonate of lime which had been converted into sulphate, and I found I had as much as 7-100ths or 8-100ths, and, in one case, 13-100ths of a grain, on a small plate about 4 inches round, converted into sulphate of lime, showing that sulphuric acid was present in the air. I further placed at the entrance to the Arnott ventilator, to use the same term, a flask of ice and salt, much in the same way as Mr. Heisch described in his evidence, and I collected on that sometimes as much as three-fourths of a grain of sulphuric acid during the day's experiment.

Am I right in saying that a certain amount of sulphuric acid would be deposited as the vapour passes through the ventilator?—Certainly.

Sulphuric acid itself does not remain in a vapour at the ordinary temperature?—In small quantities, precisely as water does—water remains in a vapour.

Were the experiments that you made in this room repeated from time to time?—Eighteen times.

By the time you performed your eighteenth experiment, all the pictures, and walls, and so on, were entirely destroyed?—There were no pictures. The walls were papered, but they were not destroyed.

Let me call your attention to a statement made by Dr. Odling on the Crystal Palace Bill, which was: "I should say, as regards the general result of my own observations, that of the very small proportion of sulphurous products that are produced, about one-tenth part of that small proportion is converted into a state of sulphuric acid, and that is in a large measure neutralized by the ammonia existing in the air." What do you say to that?—I say I entirely disagree with that, and I will give my reasons for so doing.

Sir E. BECKETT: He says, "I should say." I call that a guess.

Mr. RICHARDS: I do not. I call it an assertion, as used in ordinary conversation. (To witness:) I will now take you to Dr. Thomas Stevenson, who had made experiments with the sulphur in gas, and who found that on burning the gas only about 5 per cent., or the 20th portion, of the sulphur in the gas, as determined by the Referees apparatus, was directly converted during combustion into sulphuric acid, and that most of that sulphuric acid was neutralized by the ammonia present in the gas and in the atmosphere.

Witness: I not only dispute that, but I say that Dr. Stevenson's own evidence deliberately contradicts it.

It is a great blessing that chemistry is an inexact science?—If you refer to Dr. Stevenson's evidence you will find that, so far from bringing out 5 per cent., he himself brings out 40 per cent.; and, in the same way, i you work out Dr. Odling's, you get 60 per cent. The apparatus I used was the Referees ordinary test for determining the sulphur.

Re-examined by Sir E. BECKETT: From the table handed in by Dr. Odling, taking the grains of sulphur per 100 cubic feet of air, in a room of 3800 cubic feet, where the gas had been burning for upwards of five hours at the rate of 15 cubic feet per hour, it was found, at a height of 1 foot 6 inches from the ceiling, to give a mean of 0·160 of a grain per cubic foot; at a height of 5 feet 6 inches from the floor, 0·056; at a height of 8 feet 6 inches from the floor, 0·059. If, in the first instance, the mean of those results was taken, and multiplied by 3800 cubic feet—the capacity of the room—that would amount to a total of 3·32 grains of sulphur contained in the room in the form of sulphur products at one time, which would be just as much as would be produced by gas burning for 40 consecutive minutes. In other words, if the room was ventilated so badly—and it would be extremely bad ventilation if the air was only changed once in 40 minutes—all the sulphuric acid formed by the combustion of the sulphur would be found in that air, according to the results of Dr. Stevenson and Dr. Odling.

Sir E. BECKETT: I have gone over the figures, and I make the same results.

Witness: I take it further, and if you go on to Dr. Stevenson's experiments you find that he carried those experiments on in his drawing-room, which differs apparently 40 feet in capacity from the experiment-room which was used by Dr. Odling and Dr. Russell; and, if you take that room as being something like the same shape, and multiply out the surface area of the walls and ceiling, and take the average deposit of combined and free sulphuric acid on the different plates which Dr. Stevenson exposed, the average amount deposited on the walls will equal 3·05 grains of sulphur, or 9·42 grains of sulphuric acid per hour; and, if you add those two results together, they will come in excess of the total amount of sulphur present in the gas, and Dr. Odling and Dr. Russell's alone are as high as my best results. Dr. Stevenson's are about 42 per cent., which is about my average.

In short, you agree?—When the figures are properly worked out, the experiments are the most striking confirmation of the presence of acid that you can have.

Gases diffuse freely among vapours, do they not; and although sulphuric acid is heavier than common vapour, it diffuses quite freely through it?—Quite so. Water is heavier than common air, and yet we know that the air is partially saturated with watery vapours.

Mr. MICHAEL: Do I understand you mean to say that the sulphuric acid exists in a room in the form of vapour?—Certainly, as water does.

The COMMITTEE: Have you made any experiments of the process of purification of these sulphur compounds by peroxide of iron?

Witness: I have made no special experiment on that, but I am pretty fairly aware of the general results.

Are you able to say what degree of purity from the sulphur compounds can be attained by the use of the peroxide of iron process, if properly carried out, without having recourse to the lime process?—That would depend a very great deal upon the character of the coal used; but taking the average character of the coal used in the London gas-works, I have no doubt that 33 grains, or 35 grains, may very easily be accomplished.

As an average?—Yes, as an average; and perhaps you might even say 37 or 38 grains as a maximum; but if coal of a sulphurous character is used, it would be very greatly increased.

Mr. *Thomas William Keates*, examined by Sir E. BECKETT.

I was examined upon the Crystal Palace Gas Bill, but wish to say a word about the lime produced just now by Mr. Anderson. I have made an examination of that lime, and find it is almost free from sulphuretted hydrogen. The object of the process, as he has explained, is to draw the sulphuretted hydrogen away from the lime, and that is most effectually done here. These two samples [producing the same] represent the different layers of the purifiers. The one which was exhibited to the committee represents the upper layer, and this, which is in a damper form, having the very same smell, represents the lower layer. In the upper layer there was only ·33 of sulphide of calcium present; in the lower layer only ·45; so that practically it is free from sulphide of calcium, and is converted almost entirely into carbonate of lime. I heard the evidence given by some of the managers as to the enormous quantity of lime they thought it necessary to use, and it appears to me most extravagant. Mr. Anderson tells me he uses a quantity of lime, which is altogether different from anything which I have heard stated here. The quantity he uses is equal to only 2-10ths of a bushel per ton of coals—that is, 2-10th of a bushel of slaked lime. It was stated by Mr. Evans, I think, that the usual practice is to take a bushel of lime to a ton, but I do not know whether that is a bushel of caustic lime or of slaked lime.

Mr. EVANS: Caustic lime.

Witness: That would be equal to two bushels of slaked lime; but, to continue that subject a little further, I may say that the quantity of lime used in gas-making, so far as I understand it, is out of all proportion to anything like the theory of the thing. Of course I do not mean for a moment to say that anything like theoretical perfection can be reached in these instances. In the first place, you have to deal with impure materials; in the next place, the processes themselves cannot be applied so perfectly as they might be to secure anything like theoretical results. But the theory of the thing is this: Take 100,000 cubic feet of gas, containing, say, 40 grains of sulphur to be reduced to 20 grains per 100 feet, that would necessitate the use of 30 lbs. of sulphide of calcium. Now, if you want to reduce 40 grains to 30, it would only be necessary to employ 15 lbs. of sulphide of calcium. The make of gas at Beckton is, I believe, about 15 million cubic feet per diem; to reduce 40 grains of sulphur in that gas to 20 grains would require about 450 lbs. of sulphide of calcium; to reduce 40 grains to 30 grains it would require only 225 lbs., and I am very much corroborated in that view by a publication of Mr. Mann, who is very well known as a gas engineer in London. He was for many years gas manager to the old City of London Gas Company, and ceased to hold that office when the companies were amalgamated. I knew nothing of his publication when these calculations were made; but I find that he agrees with me exactly in a letter published in the JOURNAL OF GAS LIGHTING of February, 1875. He there says that 11½ tons of sulphide of calcium would reduce the

sulphur of 800 million cubic feet of gas from 32 to 10 grains, which works out to the same figures that I have here—that is, 30 lbs. to the million. I am not saying for a moment that I think any gas company could do it; but that is the result of the calculation. I said in my evidence on the Crystal Palace Bill that I thought the limit as to sulphur might be enlarged a little, but I think the Gas Referees are far better qualified to judge of the matter than anybody else outside the works, because they have statutory powers which enable them to go to the gas-works whenever they like. I have been in constant communication with them from the time of their appointment, and I am bound to say that they all appear to be most desirous of fulfilling their obligations both to the public and to the gas companies.

Sir E. BECKETT: Do you believe that anything, except the existence of some such body, with a control and power to vary, according to the requirements and according to the circumstances, can keep the requisite pressure upon the gas companies?

Witness: I think there is great advantage in having that elastic machinery to work with. If you fix a hard and fast line, there are no means of altering it, no matter what improvements take place. You are bound by that, and you must come to Parliament to get any change in it; but where a body like the Referees exist, they have the power to relax whenever they like.

There is a provision in the Act, independently of the Referees, that the gas shall not contain sulphuretted hydrogen at all; but is sulphuretted hydrogen in burning gas (I do not mean in leaking gas) any worse than sulphur in any other form?—No, I think not; it burns into the same compounds. If you burn sulphuretted hydrogen you get the same thing as you get if you burn bisulphide of carbon; there is merely the difference of its being a hydrogen compound instead of a carbon compound.

As a practical matter, do you believe after all that there is any real difficulty in keeping the quantity of sulphur below 30 grains?—In answer to that, it is constantly, and has been for years past, kept below that. I also think that lime can be treated in such a way as to do away with the nuisance during its removal. There are means of taking out the carbonic acid without the use of lime. Mr. Livesey pointed out that he had been using Hills's process of separating ammonia and the ammonical liquor from the carbonic acid and sulphur, and that he used the liquor so prepared for taking the carbonic acid out of the gas.

He stated also, I think, that the quantity of sulphur, apart from sulphuretted hydrogen, which is left in the gas before it is purified, is only 30 grains, or thereabouts?—Yes; but I think that is a great deal too low.

You mean, in fact, that there is a great deal more left in?—There is. I find in the sulphur reports of the Gas Referees in January, 1872—which is an account of a large number of experiments made at Beckton—that the quantity is very far in excess of what I state.

The experiments went on for some time, and there are weekly averages taken?—Here is Oct. 7 to 20, which is a fortnight, an average of 48 grains; Oct. 21 to Nov. 3, a mean of 46·4 grains for the first week, and 47·8 for the second; Nov. 4 to Nov. 10, a mean of 46 grains; Nov. 11 to Nov. 17, a mean of 43 grains; Nov. 18 to Nov. 24, a mean of 44·9; Nov. 25 to Dec. 1, a mean of 44·3, and then after that they are irregular.

How is the difference between 30 grains and 48, or whatever it may be that is actually left, to be dealt with? Supposing that 30 were placed as a minimum, would you have to use lime?—I know of nothing else but the use of lime. The figures I have read represent the state of the gas after the oxide of iron purification, as I understand; that leaves in the whole of the sulphur products other than sulphuretted hydrogen.

It seems impossible to get it down to anything like 30 grains without using lime?—That is the experience of the Gas Referees—or was.

Mr. MICHAEL (in cross-examination): Do you wish the committee to understand that it makes no difference to the consumer whether the gas supplied to him contains an equal quantity of sulphur in combination with hydrogen, as opposed to a similar quantity of sulphur in combination with carbon in various forms?

Witness: No, certainly not.

Whatever may be the theoretical non-difference between those two chemical compounds when burnt, it does make a great difference whether or no sulphuretted hydrogen is taken out of the gas?—I should say it makes a great difference, and I think that the Legislature for years past has always made it a *sine quâ non* that the sulphuretted hydrogen should be taken out.

Mr. MICHAEL: Do not think I am in any way at variance with you. I simply want your answer to be thoroughly explained, in justice to the committee, to myself, and yourself. I did not think you, wished the committee to understand that it made no difference whether it was in combination with carbon or hydrogen. May I direct your attention to the evidence you gave with respect to this very matter in 1874, upon Mr. Anderson's process:

Is it possible, as the result of that process, that there should be no sulphur in the gas and no sulphur in the lime, or in any portion of the lime, that is removed from the purifiers?—No; it is impossible.

Some of the spent lime, then, must be in a different condition from that which you analyzed?—Yes; as I understand Mr. Anderson's system, it is this: He uses a number of purifiers, and he works those purifiers in such order that the lime in some is always being converted into carbonate of lime, while it remains in a state of sulphide of calcium in others. As I understand, it comes to this: He begins with the series of four purifiers, and he passes the gas through No. 1 till the whole of No. 1—we will assume for the sake of argument—is converted into carbonate of lime.

That is for the purpose of getting rid of the carbonic acid out of the gas, which we all acknowledge is desirable for illuminating purposes.

He maintains a sufficient margin of lime in those purifiers to be enabled to take out not only the sulphuretted hydrogen which is proper to the gas itself, but also the sulphuretted hydrogen that has been expelled from No. 1 purifier, that must always be going on. When he has thrown out No. 1, to take out the carbonated lime, and replenished it, he must still have a margin to carry it on with. He must always have enough lime in the purifiers left, not only to purify the gas itself, but to purify the gas that has taken up an undue quantity of sulphuretted hydrogen from the purifier.

Supposing Mr. Anderson goes on purifying with lime for 12 months, and during the whole of that 12 months he does not remove any sulphur in his lime, where does the sulphur go to?—There must be an end of it at last, that is very clear, and at some time or other he must clear out his purifiers, sulphide or no sulphide.

Do you wish to add anything to that?

Witness: I may say that is very much altered by the explanation that Mr. Anderson gives, that he uses, after he has employed this lime purifier, oxide of iron, which gets over the whole difficulty.

Whatever may be the fact theoretically in the laboratory, is there not a great difference in carrying out the process practically on a large scale?—Of course; but if a maximum of 30 grains were allowed, you would be able to purify the gas with so much less lime, and then it would cease to be a nuisance. I think 30 grains is the extreme limit which ought to be allowed, and if there should be 5 or 10 grains above, it should be taken out.

May there not be at the present time (you told us Mr. Anderson's process is an improvement on something you heard in 1874), something which, in accordance with the evidence given before the committee, would reduce the average to 33 grains?—There is no single reason for such a thing. The gas in this case was purified by oxide of iron; the coals are a mixture of all sorts; and I see no reason why there should be any difference at the present time. I do not say there is no change, but there does not appear to me to be any reason to believe that to be the case. I consider the sulphur ought to be kept down to 30 grains, no matter what means are used.

The COMMITTEE: Do you speak of 30 grains as an average or as a minimum?

Witness: An average.

Therefore the difference between you and Mr. Michael is between an average of 30 grains and an average of 33?—I thought the committee suggested 35.

A maximum of either 35 or 40—either 35 over a week, or 40 over three days?—It appears from what I have read, from these elaborate series of experiments carried on for a long time, that the amount of sulphur in the gas exceeds 33 grains.

Do you think that in Paris and in London the sulphur compounds are different?—I only know from the evidence I have heard, but I think very little is known of that question in Paris. I think it is quite clear that the Paris gas is not so well purified as the London gas.

Mr. *Thomas Hawksley*, examined by Sir E. BECKETT.

I have been engaged in designing and looking after gas-works in England and on the Continent for between 40 and 50 years, and during a great part of that time I have turned my attention to sulphur. I have no recollection of ever having appeared in opposition to a company before; nor would I do it now if I thought that this was not a case that required the facts to be explained. I think the companies have generally been more sinned against than sinning; but this is the opposite case, and they seem to have gone boldly into sin now they have started.

At the request of Sir E. BECKETT, the CHAIRMAN repeated the suggestion made in the early part of the day—viz., that the maximum should be fixed for the present at 40 grains if the average was taken on three days, or 35 grains if taken for a week, and that it should be subject to variation only by a direct order from the Board of Trade, and also that the company should give every facility to the Board of Trade to make such experiments, under such conditions as the Board might desire, upon their works. There was likewise a further question to be considered, as to how the financial result or saving in that change of procedure should be received or enjoyed either by the public or the company.

Sir E. BECKETT: Having heard that, what do you say would be the effect upon the company?

Witness: The latter part of the suggestion is exceedingly valuable. How it would operate upon them and their dividends it is impossible for me to say, but with regard to the proposed limit of 40 grains I have to say——

The CHAIRMAN: That is the maximum?

Witness: Yes, but it is an average maximum. They may be at 50 grains one day, if they will come down to 35 on two other days, and that would amount to (if I may use such an expression), poisoning the consumers on two days out of the three, in order that they might be relieved of 5 grains on the other one.

You mean that if the Acts, going as far back as the Act of 1860, had not been passed, they would probably have given us no more than 40 grains?—If there had been a thorough good purification in other respects, good washing, taking out the ammonia, and a previous washing with ammoniacal liquor for taking out such sulphur compounds as the alkaline and the ammoniacal liquor will take out, then there ought not at most to be more than 40 grains left after purification from sulphuretted hydrogen; so that, in fact, it is repealing the law entirely as it now stands.

The two practical issues we all see; and, first of all, the influences of, I will say, the difference between the 20 grains and the 40; and, secondly, the possibility of getting rid of this 20 without nuisance. First, as to the influences between 20 and 40, what have you to say about that?—Let me first explain, as it stood yesterday, with 35 grains, that would be the means of distributing into the houses of the consumers the equivalent (and it would be performed to a very large extent) of two million pounds of sulphuric acid per annum, and if it did not pass into sulphuric acid, and were only sulphurous acid, there would be more than a million and a half pounds so distributed through the town. I have seen the effects where gas has not been properly purified, and the effect would be, taking a mercer's shop, that the exposed edges of all silks in the upper part of the room would be bleached. Sulphurous acid has great bleaching power; it removes colouring matter, and has a great many other injurious effects. It affects the throat very sensibly, and communicates a nasty coppery taste in the mouth. I am a gas-maker in many parts of the kingdom, and I do not want to exaggerate the effect, but I regard this as a very retrogressive movement.

Sir E. BECKETT: Now, although two million pounds of sulphur are not to be sent into one house in the year, would that be enough to make a very sensible effect over all the houses?

Witness: Very sensible. I do not mean to say that if in a great room like this you had a good ventilating-pipe out of the corner, as I have in my dining-room, that you would suffer very much from it; but taking all the ordinary cases of habitations and shops, and workshops particularly, the mischief would be very considerable.

That is one part of the story; the other part is the nuisance question. What do you say as to the possibility of reducing the sulphur to 20 grains without any nuisance?—There ought to be no nuisance by reason of reducing it to 20 grains. A gas-work is not an agreeable neighbour, but the smells which come from thence are not in general created by the sulphur, if the process be properly conducted. Of course you may make a great nuisance by an improper way of purifying the gas, or of treating the lime after it has become refuse. At Nottingham we can, without any difficulty, keep the sulphur, other than sulphuretted hydrogen, down to 15 grains. I have also had to do with Derby, Sunderland, and other large towns, in great numbers, where lime is used, either by itself or in conjunction with oxide of iron. Where lime is not properly used, it can be made a nuisance, and many gas companies do make an unnecessary nuisance—I am bound to admit that—but by properly conducting their operations, both in gas-making and in dealing with the waste lime, there need be no nuisance whatever. The process of gas-making in London, as it is generally known, is a very bad one. It is very imperfect, and might be very much improved; but, in point of fact, in some places they try to do too much in a very limited area, and out of that particular circumstance arises a great deal of the trouble which the gas companies get into.

I suppose they will say that they cannot help their area being limited?—Yes, they can; at least, this particular company can. They have got very large means, and need not be making the great quantity they are doing at Fulham; or at the little place which used to be the Equitable works; neither need they be pressing other stations to the extent they do. I remember the time when Mr. Cardwell's committee suggested amalgamation, which was with a view to getting rid of the manufacture of gas in the heart of London; and it has had that effect. For instance, the City Gas-Works are discontinued as a place of manufacture.

It has been suggested that the men suffer from removing the lime, and so on; have you found that to be the case in other gas-works which are properly managed?—The men do not suffer from the removal of the lime; they suffer rather more from preparing the lime than from removing it.

With reference to the preparing, is that necessarily an unhealthy process?—It need not be, because it may be done mechanically if they choose to do so; therefore, of course, it would not be injurious.

The only remaining point is with reference to the powers of the Board of Trade to vary this maximum from time to time, and that has to be contrasted with the power of the Referees. Do you see how the Board of Trade can act in this matter except through some officers, whatever those officers may be called?—I have the pleasure of knowing all the Referees, and I know they are very competent people; they are scientific men, and they know enough of the practice of gas-making to guide their science, so as not to make mistakes; and I also know that the limits which they have prescribed from time to time are fair, and such as the companies, if they would only make their gas by a proper process, could fairly and reasonably adopt and comply with.

Supposing the Referees were abolished by name, can you see any way by which the Board of Trade could act, except by having some similar officers, but who would be called something else?—No; there must, I suppose, be some control, although the Bill seeks to get rid of all control, not only with respect to sulphur, but with respect to all impurities whatever.

As the Referees exist, and assuming them, for the sake of argument only, to be competent, supposing they came to the conclusion that it would be impossible to do this work without a nuisance, can you see any reason why they should not relax their conditions?—No: the Referees can to-morrow, if any reason is shown why it should be so, make their limit 25, 30, 35, 40, or 50 grains. They can make it anything they like; but if it is

done by Act of Parliament it is done rigidly, and without any regard to what might be an improvement in gas manufacture.

But that is not the committee's proposal. The present proposal is, that the Board of Trade should have the power of reducing the 33 or the 40 grains, whatever we call it, below that amount whenever they think fit. I ask you if there is any advantage in that over the Referee system?—No; it amounts to the same thing, I should say, in the end. It is 33 grains, as I understand, with a power of diminution.

Whereas it is now 20, with a power of raising it?—Yes, and it is raised; it is 25 in winter.

So that the introduction of anything like the recognition of 33 or 40 grains would be very nearly doubling the maximum which they have been allowed for the last 17 years?—Not doubling, but adding two-thirds to it.

Examination continued: I have burnt the Chartered Company's gas for nearly 30 years, and am satisfied with it; it is not very rich in illuminating power, but it is a very pure gas—reasonably pure. Some time ago I had cause to complain, because my office, which consists of several large rooms, was perfectly unbearable, and that was within half an hour after the gas was lighted. I applied to the company, and they sent one of their people, who looked round my room—not knowing who I was, or what I knew about gas—and he said, "Oh, it is your burners." That is the staple answer or suggestion of remedy; but my burners had been there long before, and are there still. The company paid no attention, and so I wrote a letter to the Gas Referees, and they took some steps (what they were I do not know), but after a short time the gas became quite pure, and I have had no cause of complaint since.

By the COMMITTEE: I should think that took place three or four years ago; but I can show you something which is very interesting. This [producing a bottle of water] was taken out of one of my gas-pipes, not experimentally at all, but was the result of less than two hours burning of three gaslights in my drawing office. A chemist will follow me who will tell you what are the contents of this water in sulphur, and also tell you how acid it is, and that it destroys the iron of the pipes. He will show you the iron in it.

Sir E. BECKETT: Before the chemist comes, will you just explain how that water was actually obtained?

Witness: I have in one of my offices three gaslights over a drawing-table, and those communicate by a ventilating tube with a horizontal pipe which carries the products of combustion into the chimney; that pipe is cold, and condenses the products of combustion into water, or rather into this liquor which I have here. That is drawn off by a descending pipe into a vessel, and out of that vessel it was poured into this bottle, and this was the result of less than two hours burning of three Argands.

It is the distillation of the gas vapour?—In the ordinary course, and I can bring you pints of it from my office, in which every light is ventilated; and from the pipe which conveys off the products of combustion I can get this liquid in quarts at any time. It is not, of course, the amount of liquid, because the consumption of gas results in the formation of water, but it is what the contents of it are. You will find plenty of acid in this if you have a bit of litmus paper.

By the COMMITTEE: I have a bell over each light, and they go into one tube, which tube communicates with the chimney. About 5 cubic feet of gas is consumed by each burner, making 30 feet. [The litmus paper was produced, discoloured.] Now they say that there is no sulphuric acid generated. Just look at that.

Sir E. BECKETT: I hear it stated that sulphurous acid will do the same?

Witness: Sulphurous acid dissolved in water will, but I have no doubt this is sulphuric acid. At all events, you see the effect of it; it does not matter what it is, whether it is called an acid or not.

Examination continued: Purifying gas properly ought not to cost more than a penny per 1000 feet above what it costs to purify it improperly. I have some knowledge of the Paris gas, which was spoken of yesterday. I know there they manufacture their gas by a very much better process than the one which is adopted in London. They work with four-hour charges, whereas in London they work with six-hour charges, and the

result is that they produce in London more of this obnoxious compound than would be produced by a more rapid distillation of the coal, and not draining it to the dregs, as they do in London. I believe the bisulphide of carbon is produced in this way:—There is, especially at the latter part of the charge, a good deal of carbonic acid, and also carbonic oxide, and there is likewise sulphuretted hydrogen coming off from the coke, which contains a good deal of ferruginous matter with which the sulphur is commonly combined. Now the way in which it happens, I believe, is this—that two molecules of sulphuretted hydrogen are combined with one molecule of carbonic oxide, or it may be carbonic acid, the result of which is the formation of bisulphide of carbon, which is a very obnoxious matter; and if it be with carbonic acid, then one equivalent of oxygen is set free, and that may account for the small quantity of free oxygen which is always found in coal gas, and which has been a difficulty, as far as the theory goes, hitherto. If they work off the charge, as I do in a shorter period in these provincial works, and particularly if they worked it off in the manner which is adopted in Paris, I have no doubt they would have less of this obnoxious compound. The next thing to do is to wash the gas well with ammoniacal liquor, and that absorbs an enormous quantity of bisulphide of carbon—so much that the ammoniacal liquor stinks abominably. Then there is less to go forward to the next process of purification, which ought to be passing the gas through oxide, to take out all the sulphuretted hydrogen. There ought next to be lime, for the purpose of taking out the carbonic acid, because the two can be taken out together, and I do it constantly, notwithstanding all that has been said to the contrary. Then the gas goes on to what is called the catch purifier, filled with oxide of iron; and if any sulphuretted hydrogen passes over, it is caught in that vessel. The process is very simple, very economical, and very sure in its results; and the lime, instead of coming out in the obnoxious state in which it ordinarily does from the purifier, comes out very nearly white, without a very obnoxious smell, and is only coloured by sulphur in a pyrophoric state diffused through it.

Sir E. BECKETT: To sum up, do you think that, on the balance of convenience and inconvenience, between leaving an extra 20 grains of sulphur in the gas and running the risk of the nuisance of purifying it, the balance on the part of the public is in favour of having their gas kept pure?

Witness: Undoubtedly.

Cross-examined by Mr. RICHARDS: It is not a question of conduct on the part of the gas company, because they are obliged to be good boys at the present time; but they come here for leave to be able to behave as they please. I consider that the company are doing too much work upon particular areas of land, and that their apparatus is not well adapted to the requirements which Parliament has imposed upon them. The company are doing too much at Fulham, and also at Pimlico.

Mr. RICHARDS: Do you know what they are doing at Fulham, and that for the last year a large portion of the Fulham district has been handed over to Beckton?

Witness: No, I cannot answer that. All I know is what they say they are doing.

By the CHAIRMAN: With regard to the alleged nuisance in the neighbourhood of Kensington, I may mention a fact within my own knowledge. I happen to live in that district myself, and the great nuisance there is not from the gas-works, but from a brick-kiln, which many persons take for a gas nuisance.

Cross-examination resumed: We had a complaint exactly similar to that of Mr. Veitch, made at one of the Nottingham works, some years ago, by a florist; and what the company did was to set up a flower-garden in the works, and the flowers grew so beautifully that they never had a complaint afterwards. I do not wish to suggest that the engineers of the company have not done their best to prevent a nuisance, but, from what I have heard in this room, the process which they adopt for the purification of gas is well calculated to make a nuisance. They are very intent on purifying the gas by sulphide of calcium, and, as I understand, use the foul lime for the purpose of taking out the bisulphide of carbon; and if that is done, it will to a certainty make a nuisance, for the gas lime is a

most offensive thing. It need not be done in that way, because there is no occasion to bring the sulphuretted hydrogen at all in contact with the lime. The lime, as I have mentioned, will take out the bisulphide of carbon when it is in a pure state, and it does not require to be made impure for that purpose. One ton of lime will purify the gas of 40 tons of coal, both from carbonic acid and bisulphide of carbon, and that after you have taken out the whole of the sulphuretted hydrogen. That is what I did at Nottingham.

Mr. RICHARDS: What is it that makes such an abominable stench at Nottingham at the present moment?

Witness: Nothing. No gas-work is free from smell; the oleaginous and ammoniacal matters which are produced in the distillation of coal always produce a smell, but that is a very different thing from the smell of the foul lime.

I understand you to admit that the sulphur compounds must be got out in order to meet the requirements of the Referees, and that necessitates the use of lime to get them out?—Yes; but the use and removal of the lime may be so managed as not to produce an obnoxious nuisance.

You also think there should be shorter charges—that is to say, that the retorts should be filled at more frequent intervals?—I do not say that is a *sine quâ non*. I am merely telling you how the Paris people conduct their works, and how it is in the country works of mine. I can also tell you that in Scotland (but they use a different coal there) they work with three-hour charges.

The CHAIRMAN: What, in your opinion, is the degree of purity from sulphur compounds—exclusively, of course, of sulphuretted hydrogen—which can be attained by the peroxide process, without recourse to the lime process?

Witness: That would vary according to the quality of the coals. Many coals contains as much or more than half a hundredweight of pure sulphur in a ton; the Midland coals do.

But the kind of coals which are used in these large works?—They use all kinds, and there is a difficulty in answering the question without an explanation. The best gas coals do not contain more than 40 lbs., and, therefore, the question is not so easily answered; but I should think, taking the Midland coals, that there are quite 50 grains of this bisulphide compound in 100 cubic feet. Taking the north country coal, I do not believe that there are more than 35 or 40; but it is a question very difficult to answer, because in the crude gas, as it reaches the purifier, or, rather, the commencement of the process of purification, the sulphur very often amounts to 250 grains.

What I want to know is this: Supposing a limit is fixed for this city company—we will say an average of 35 grains—will they be able to attain that degree of purity without having to resort to the lime process?—I should think not.

What degree of purity do you think they could obtain?—It would rather restrict them as to the purchase of their coals, which will be a very undesirable thing; but I should think that they could find coals which would bring the quantity down to about 40 grains.

Do you mean an average of 40 grains?—Yes; but I do not know exactly what is meant by average, because that is a very uncertain thing. You might have a very impure gas one day, and a very pure one the next.

Mr. Keates said he thought the companies might be allowed safely and properly to go to an average of 30 or 33 grains of the sulphurous compounds in the manufacture of their gas; do you agree to that?—No; I think you would perceive the effect of that in a close room. I think the 25 grains fixed by the Referees is as low as it would be prudent to allow. If that amount is right for winter, I do not see why it is not right for summer; that is the difficulty, I see, in the Referees instructions.

You seem to me to have a very strong objection to this principle of average, but suppose the average was 35 grains, would you then say that, for the sake of a relief of five grains on one day out of three, people are to be poisoned for the other two days—that is to say, by an increase of two and a half grains?—No. I have been very much misunderstood, or

have very inaccurately explained myself, if I have been supposed to say that.

You terrified us when you began, because I took down your words that "people were to be poisoned on two days in order to give a relief of five grains on the other one"?—No; what I say is this—that if you have 35 grains on two days and 50 on another day, it does not at all relieve the people.

The CHAIRMAN: What I understood you to say distinctly was, that the public would be poisoned for two days in order to give them a relief of 5 grains on one day, and that is a very serious thing.

Sir E. BECKETT: "Poisoning" is, of course, a metaphorical expression.

The CHAIRMAN: If it went forth to the public without some qualification it might produce a very injurious effect.

Witness: I was not in earnest in using those words, and, with very great deference to yourself, I do not think I used the words "being poisoned on two days," but I think I may have used the expression, "being poisoned one day out of three," because you may have a very large quantity of sulphur on one day, and from that the public would suffer, while that quantity might be corrected down to the average by the two other days showing a very low quantity comparatively.

The CHAIRMAN: You may have intended to say that, but you stated exactly as I tell you now. With regard to another of your answers, you spoke of distributing 2,000,000 lbs. of sulphuric acid; you do not say exactly where, but I suppose if that were extended over the three kingdoms it would not do much harm; and, therefore, it depends entirely upon what area it is to be extended over?

Witness: It is a practical question—Can you perceive it by the nose, and does it produce injurious effects on delicate goods? I answer in both cases in the affirmative from experience.

By the COMMITTEE: When I used the word "poisoned," I did not mean poisoned to death—that is quite a different thing—but what I meant was, poisoned in the sense of the quantity of sulphur being then very obnoxious, and in amount sufficient to do injury both to health and goods upon that one day out of the three. Supposing myself to be in the position of President of the Board of Trade, and that the committee had stated their conviction that 40 grains was the proper limit, I should be very careful indeed about taking any steps to impose a lower standard of quality upon the companies.

The COMMITTEE: In one of the letters which has been put in, from the Referees to the Board of Trade, they admit that there is much to be said in favour of the view that the presence in gas of sulphur, which the lime process removes, is of no great consequence to the consumer?

Witness: That depends entirely upon the state of the consumer's ventilation. If the consumer will make perfect ventilation in his house, which very few consumers will make, then it is not of much consequence; but under the ordinary condition of houses, I have no hesitation in saying that it is of considerable consequence, and in workshops particularly.

The COMMITTEE: The proposition referred to is as follows:—"While admitting that there is much to be said in favour of the view that the presence in gas of the small amount of sulphur which the lime purification removes is of no great consequence to the consumer, we are still of opinion that it would be a measure of questionable expediency to relieve the companies altogether from the obligation to make and supply gas as pure as can reasonably be required, because the main inducement to invention and effort in this direction would thus be removed."

Witness: What the "because" means I do not know, but stopping at the word "required," I agree with the sentence.

The COMMITTEE: Do you agree with the admission that there is much to be said in favour of the view that the presence of this small additional quantity of sulphur is of no great consequence?

Witness: Yes; but there is very much to be said on the other side.

Mr. *Charles Heisch*, examined by Sir E. BECKETT.

I examined the water which came out of Mr. Hawksley's gas chimney, but I have not had time to make a quantitative analysis of it. I precipi-

tated half an ounce of it with chloride of barium, to which I added a considerable amount of hydrochloric acid, to make sure that nothing but sulphate of barium was precipitated. I have here a bottle which will show the amount of iron which is taken up from the pipe [producing a bottle]. This is the iron in solution, which was precipitated by ammonia, and it will give an idea of the amount of the corrosion going on in the interior of the pipe.

By the COMMITTEE: I cannot say how long that pipe has been in use.

The COMMITTEE: If it goes on at that rate every two hours, it will not last very long?

Witness: That is what is in solution in this particular quantity of water. Of course, the whole corrosion of the pipe would represent a good deal more than that; but I can mention, as a matter of experience—because I have tried it—that if I start with a perfectly new pipe, I find that about one-half of the sulphur existing in the gas burnt is condensed in the pipe in the form of a sulphide of the metal of which the pipe is made, provided it is a metal on which sulphuric acid acts.

Examination resumed: I have heard of the proposal to substitute the Board of Trade, acting through somebody, for the Referees; but I do not think it would make any difference, except that it would give them a starting position, which the Referees have not. I should not like to go to the gas-works for the purpose of making experiments, because it would require a combination of elements which I do not possess in my own person. To make those experiments properly a man ought to be a mixture of a chemist and a gas engineer.

Sir E. BECKETT: Take this hypothesis. If we suppose the company themselves undertake to make the experiments, would you like to be bound by the results, supposing you were a Referee?

Witness: I do not think I should. It would depend so much upon circumstances what the experiments were. The carrying out of experiments in that way is a thing which it is difficult to do without interfering with the works to a certain extent. If it were merely trying certain modifications of processes in use, that is one thing; but if it is trying an absolutely new thing, it is another.

Mr. MICHAEL (in cross-examination): Putting yourself in the position of a chemist, and assuming that you had devised in the laboratory some mode which you had proved in the laboratory to be successful, you would not consider that successful until you had an opportunity of trying it on a large scale?

Witness: No.

What could you wish for better, if you have confidence in your experiment, than to have it tried upon a large scale at the gas-works, where practically you could test the system which you had elaborated in your laboratory?—I think that would depend a good deal upon the amount of assistance which you could obtain in the engineering part of the business from the engineer of the company. If he were willing to take the thing up, and willing to help you over the engineering difficulty, and you to help him over the chemical ones, I would wish for nothing better.

All you want in the gas-works is the presence of gas in large quantities to be purified; that will be the first primary condition, of course?—That is the primary condition, of course.

What difficulty would there be in the Board of Trade sending their own engineer to put up the box which you had invented in the laboratory?—I should think there would not be any difficulty in that.

The COMMITTEE: There have been experiments conducted by the gas company, at the instance of the Board of Trade, at considerable expense. Were there any complaints of the way in which those experiments were conducted on the part of the Board of Trade at the gas-works?

Witness: I am not aware of that.

Whatever Mr. Vernon Harcourt has suggested has been tried?—I can give no evidence about that.

At the conclusion of Mr. Heisch's evidence the CHAIRMAN said the inclination of the committee was to give some such relief to the gas company as had already been suggested at an earlier period of

the day. They were the more inclined to do so, as on the balance of convenience they thought the injury to that part of the public which suffered by the process of lime purification was on the whole greater than the inconvenience suffered by the public through a slight increase of the maximum of the sulphur compounds, other than sulphuretted hydrogen, permitted to remain in the gas. It was not, therefore, in any way to relieve the company from the bargains which they entered into when they obtained their Act last year, and it would be for those who represented the public to make any suggestion they thought fit, and support it by such evidence as they might require, as to whether any alteration should be made in the price at which gas was in future to be sold by the company. The committee would also like to know, as exactly as possible (because up to that time there had been some little difference of opinion on the subject), about what the minimum of sulphur impurity obtainable in gas, without using the foul lime process, would be. Besides that, the committee would have to take care that the clause (should they agree to vary the clause as it stood) should be drawn in such a way as to give the most ample opportunities to the Board of Trade to make all experiments they might think fit under the most favourable conditions.

Mr. CRIPPS expressed a wish to consult with Sir E. Beckett, and, after some conversation, the committee adjourned.

THURSDAY, MAY 17.

Mr. *Frederick Joseph Bramwell*, examined by Sir E. BECKETT.

I am an engineer, and have given evidence upon a great many gas inquiries. I have visited several gas-works, both at home and abroad. As regards the question of nuisance, I do not consider that the evidence which has been given by the Chartered Gas Company is at all conclusive, neither do I think that the best means have been adopted to prevent it. From my own knowledge, I am convinced that there are means of carrying on the reduction to 20 grains by means of lime, without imposing any nuisance on the neighbourhood.

Sir E. BECKETT: Evidence has been given of various conditions of things at the different works; for instance, at Pimlico, it sometimes appears there is a nuisance, and sometimes there is not a nuisance. What do you infer from that?

Witness: That at one time more care is taken than at another. I know the Pimlico works well, and I heard the evidence that was given about the nuisance created by taking the spent lime in a cart across the roadway, and shooting it into a barge. I know there is a subway along which the coals come, and through which the lime might have been taken; and it does not look to me as though that was a strong effort to get rid of the lime with the least nuisance possible. I have heard the evidence which has been given, and I agree with it as to the fact that no nuisance need necessarily be created.

Do you also agree that there is, in some cases, carelessness?—The instance that I cited just now appears to me to be carelessness.

On the question of getting rid of this lime; have most of the works railway communication or canal communication?—Yes; almost all the important works now have either railway or water communication.

Take the case of the railway, would it be easy to get the lime on to the railway without exposing it, and so creating a nuisance?—It appears to me to be so, in the following way:—Instead of putting the purifier in the open air, place it on the first floor of the building, and deliver the lime through the bottom of the purifier instead of shovelling it over the top; it could then be delivered straight down through the shoot from the bottom of the purifier into the very receptacle that you have to take it away.

That is assuming the lime is in the state in which Mr. Anderson tells us it need not be?—It is assuming the lime is in an offensive state, but I am not chemist enough to say whether it need be in such an offensive state. Some years ago I had occasion to study this matter, in connexion with one of the most offensive trades I know of—viz., bone-boiling, in which odours were emitted worse than those coupled with the notion of putres-

cence; and in that trade, by the precaution of carrying it on within a building, and having an exhaust fan to make an in-draught of air, there was no nuisance whatever outside the building.

Inasmuch as the company have now Beckton and other places out of London, they need not necessarily carry on so much work at Fulham, St. Pancras, and other places in London?—As regards Beckton, except the outfall of the Metropolitan Board of Works sewers, I do not know what neighbourhood there is to be offended. They have no neighbours to complain there—their nearest neighbour is the outfall.

You mentioned having seen several gas-works abroad; can you tell us anything about the mode in which purification is carried on?—No, except seeing the children going about to be cured of whooping-cough. At Brussels the purifiers are made with an internal framework, so that the whole of the contents are lifted out bodily, and taken away and revivified, instead of being shovelled out.

A suggestion has been made to the committee that experiments should be carried on by some new Referee or officer, or whatever he is to be called, on the gas-works themselves, by the gas people. How do you think that would work?—If the Referees have practical knowledge, they do not want the aid of the gas company; but if they want the aid of the gas company to get practical knowledge, it is asking the company to make a rod for their own backs.

And show the Referees how to flog?—Yes. That is to say, if the experiments are successful, it is to impose upon them the continuance of the purification from these other sulphur compounds; whereas, if they are unsuccessful, the suggestion is that they are to be relieved.

Would you yourself like to be a Referee, and have these experiments carried on by those whom you have to control?—I should feel that my office was really a nominal one.

Cross-examined by Mr. POPE: I have given attention to the purification of gas for the last five years. I am not a chemist, but I suppose I know as much about purification as any other gas engineer who is not a chemist. I know that at Brussels there is a purifier of lime in connexion with the oxide.

Mr. POPE: So there is everywhere; but on the question of the possibility of conducting the purification by lime without a nuisance, you are vouching continental works, and I want your knowledge on the subject.

Witness: I can only tell you of the one at Brussels, and that I have not seen; but the question put to me was not as to purification by lime; it was a question as to what I had seen. I have not seen the process of removing the spent lime at the Pimlico works, but I heard Mr. Dines's evidence, and I know those works, and also the subway, as I had particular occasion to inquire into it some years ago. That subway communicates with the river side, and if a cart containing spent lime were taken there it must necessarily shoot its contents into the barge lying upon the river brink.

Which is the precise material which Professor Tyndall said caused the nuisance?—So I understood. Will you let me state that my impression was that the lime was taken in a cart across the public roadway, on a high level, and from there shot into the barge; and I say that that was a way that was much more likely to cause a nuisance than if it had been conveyed in a truck along the subway under the road, and turned into the barge from a less height.

Do you suppose that any of the nuisance arises while it is crossing the road?—Certainly.

In what condition is it taken across?—In a cart, covered with a little earth probably, but I do not know whether it was or not.

If it is covered with breeze, it is perfectly inodorous, and there would be no nuisance created?—If it is inodorous, of course there is no nuisance.

Do you believe that it was shot uncovered into the barge?—No; I believe it was covered.

Then the whole difference would be that taking it along the subway would make the shoot less high, in fact?—Yes; but I may make a remark upon that. Either the operation is so conducted that there is no nuisance at all—and I thought that the suggestion was that there was a nuisance—

or it is so conducted as that it might be improved, as regards the descent through the shoot.

The improvement possible is a reduction of the height of the shoot?—Yes.

That is the whole of it, though you have not seen or investigated for yourself how far the nuisance arises in that way or otherwise?—I do not know whether you put to me that there is a nuisance or that there is not. If there is not, I suppose there is an end of the case; but if there is, then I think it could be reduced.

How about the rise and fall of the tide? That would increase or diminish the height of the shoot, would it not?—The road being above the subway, it is quite clear the height, whatever it is, is *plus* this fall.

I do not quite understand your analogy between sulphuretted hydrogen and bone-boiling?—I think the analogy, I will not say is obvious, but is pretty smellable—two bad stinks.

Do you yourself make no distinction between vapour given off by bone-boiling, which contains an organic stink in it, so to speak, and sulphuretted hydrogen, which is gaseous and diffusible?—I have no doubt I could demonstrate between one smell and the other.

Do you mean to say that the physical conditions of the two are altogether analogous?—I do. For the purpose of preventing the diffusion of the smell, it does not matter very much whether it is sulphuretted hydrogen or Eau de Cologne.

What is it that causes the nuisance of bone-boiling, which runs over in vapour?—I am not chemist enough to tell you. I can tell you it is a dreadful stink, but I cannot give it you chemically.

You cannot say whether it is gas or organic matter which comes over in steam?—I tell you it is partly uncondensable, I believe.

Cross-examination continued: What I suggest is that a purifier might be placed on the first floor, railway-trucks run underneath, and the lime shot from the bottom into those trucks, or else into a barge, by which means it would be quickly got rid of.

Quickly getting rid of the stuff—that is to say, taking the bottom out of the purifier?—Not taking the bottom out, but shovelling it through openings in the bottom, as is done, and as is thoroughly well known.

The COMMITTEE: Done where?

Witness: At the Commercial Gas-Works.

Mr. POPE: That is an awkard illustration, for that is the place where the maximum is raised by the Referees to 30 grains?

Witness: Yes, and where the works themselves are making at the present time, I believe, only 13 grains. I do not think there is any smell from the Commercial Works at the present time.

Then there is no necessity for what the Referees have done, in your judgment?—I believe the cause to be that at the time the Referees made that order the plant of the Commercial Company was not complete.

All you suggest is, care in the administration of this lime process?—Yes.

And you also express decidedly the opinion that lime purification does not necessarily create a nuisance, however small?—I do; that is to say, no greater nuisance than arises from the conduct of other processes of gas-works. I have likewise seen the process of lime purification carried on at Beckton without a nuisance. Supposing Beckton were in the middle of London, the whole works would be a nuisance, but I do not believe the lime process need be. As I understand the Act, the function of the Referees in lime purification is limited by whether the process can be conducted so as to be a nuisance or not. If, therefore, it be a nuisance, the companies are relieved from the expense of lime purification. My evidence is based upon the assumption that the best efforts are made to prevent its being a nuisance.

Re-examined by Sir E. BECKETT: The Commercial Company were one of those that accepted Mr. Forster's legislation of 1875, and whether the Referees have prescribed or not prescribed, I know as a fact that they are making gas with only 13 grains of sulphur left in without a trace of nuisance. My last visit to their works was about a month or six weeks ago.

Sir E. Beckett: My learned friend seems to have got some notion that there are diffusible and indiffusible smells; I have not met with the indiffusible ones, have you?

Witness: I have no notion of a smell which is capable of being laid hold of, which appears to me to be a smell which is not diffusible. I do not like to refer the committee to the lines in Pope about what will perfume a spacious drawing-room and does not weigh half a grain.

You were asked about your experience abroad, and so on; I suppose you need not go abroad to find out that purification can be done without smell when you see it done in England?—To my mind, if you get it done on a large scale in one works, that establishes the fact; just as if you had seen a locomotive running once, that would be establishing the fact that there was such a thing as a locomotive, although every coach builder and coach driver in England swore that it could not answer.

Do you know how long it is since the Commercial Company finished their plant? As I understand, it is a plant for an improved process of purification by lime?—The completion of the plant, I believe, has not yet taken place for their winter make. It was in progress when I was there, but not completed. The plant for the summer make was completed.

Did you see the process of opening the lime purifiers and cleansing them whilst you were there?—It had finished the moment before I got there.

How do you know that it finished the moment before you got there?—I was told so by the foreman. I went on board the barge, which was lying there with the stuff put into it, but I think there was a tarpaulin over it. When I took hold of the lime and lifted it, it had an offensive smell.

Until the cover was removed you perceived no serious smell?—No, but I may describe it to you very briefly. There is a house containing four lime purifiers of large size—I think 36 feet by 28 feet—upon the first floor. That house abuts upon the canal, and the material is emptied down through the bottom of the purifier into the bottom floor, and is then carried away into the barge which lies immediately outside the house.

As a matter of fact, when you say it had been a moment before, I suppose it might have been half an hour or a quarter of an hour?—It was this: "I believe we are emptying now." I go into the house: "We have just finished."

If it had been a quarter of an hour before, whatever smell there was created in opening the purifier was all over, and probably would have been removed?—I should think not, because this is in a closed building. I should tell you that the purifier was open, and the contents had to be delivered, and were at that moment on board the barge, and some were lying about. I hope you do not fancy that I am saying that there was no offensive smell within the house, but what I am saying is that it did not spread outside the house.

If any smell had escaped from the house a quarter of an hour before you went there, it would not be likely to be hanging in the air still?—No; if it had escaped a quarter of an hour before, probably not.

I have not quite caught from you the process by which you believe the nuisance, which might otherwise have been created, is avoided at the Commercial works?—The purifiers are in a close building, with only the ordinary openings, and instead of the stuff being pitched over the side of the purifiers, so as, it appears to me, to perfume the air as much as possible, it is sent through the bottom of the purifiers through four openings.

Are there layers or trays, may I ask you?—Yes.

You have not seen them working the process of getting rid of this stuff, therefore you cannot tell us in what way they clean out the lime between the trays?—The trays are lifted. When the first row of trays is cleared, that is lifted, and the next cleared, as in any other purifier.

Do you think that that is an experiment which, supposing it were successful at the Commercial works, it would be possible to have tried at the other works, under the superintendence or by the order of the Board of Trade?—I do not think it would be possible. If it is to be a Board of Trade experiment, it will be said that it is not a practical one; and if the Board of Trade, to get rid of that objection, are to put themselves in the

hands of what are called practical men, I am sorry to say I think you are asking practical men to——

Surely, as I understand you, the experiment is not only a practical one, but one which has been carried into effect in other works. Then, what difficulty can there be, if competent men are employed for the purpose, to have that process entirely imitated?—As I understand, the Gas Referees, being gentlemen of knowledge and skill, say, "It is not for us to give directions as to what is to be done; but we do know, as a matter of fact, that it can be done, and therefore we go on with our orders."

Do you believe that that decision of the Referees is founded upon the success of the Commercial Company's experiment?—I will not say upon that, but upon consideration of what really can be done. I do not call it an experiment at the Commercial Gas Company; it is a question of construction.

Re-examination continued: I have visited the Beckton works on three occasions, the last being in 1876, but I cannot say that I have been there when the purifiers were opened and cleared. All I can say is, that when I was there I observed no serious nuisance, but that is quite consistent with the fact that when the purifiers were opened and cleared there might be a considerable nuisance.

Sir E. BECKETT: Do you know enough of those Brussels works to say whether the process of lime purification there is for the same purpose as is conducted, we will say, at the Fulham works?

Witness: I do not know. But whatever the material might be that was in the purifier, it was possible to empty it out without shovelling it, by taking it out *en masse*.

The mechanical difficulty would depend very much upon the size of the purifiers and the work that they had to do?—Upon that I would say "Yes;" but at the present day we have so improved in our power of lifting weights that I know of no difficulty that could occur.

Is it your opinion that at Beckton, or at Pimlico, or at Fulham, there is no mechanical difficulty in applying such a process as you have described to us as being adopted at Brussels?—I do not believe there is any.

Would it be a very great additional expense?—If you were making the plant new I should say it would be trifling, but if you were to adopt the old plant I should think it might be a considerable cost, but it would be wrong for me to give you any suggestion upon that.

Do you think that, supposing the company were willing to go to the expense of obtaining more space, we will say at Fulham or Pimlico, that they could thereby adopt the improved process that you have spoken of, and in that way mitigate the nuisance?—It appears to me that if the process can be conducted upon their present ground in a manner which is said to cause a nuisance, that it could be conducted on their present ground in a manner that would not cause a nuisance; but following that, I do not see how the mere increase of ground, without improving the manner adopted on the present ground, would prevent the nuisance.

Re-examination continued: As to the saving of expense to the gas company, supposing that they were not required to use the lime process, that is a matter upon which I would rather not offer any opinion at present. I consider that the evidence of the promoters is not conclusive, because they attempt to negative the proposition that purification can be done without a nuisance, while I believe it can be.

Sir E. BECKETT: How is this matter of taking out the trays managed at the Commercial works?

Witness: They change the top tray first, then take it out, and then empty the next tray.

Do you shovel it over the top of the purifier?—They shovel it down the shoots; it comes through at the bottom.

Mr. POPE: They must take the top off before you can get to the top tray?

Witness: Yes.

What is the difference between them—one goes over the side, and the other down a hole in the middle?—If it does not commend itself to your mind as being a difference, it does to mine. One thing is, that the purifiers are under cover; and the other is, that, being under cover, the stuff is shot down through openings in the purifiers.

By the COMMITTEE: If a man is in one of the purifiers, he has the stuff to shovel out into a sort of watch-box, and there is far more probability of the air being impregnated with odour than if it is simply turned down alongside the shoot which stands up through the bottom. There are four shoots which stand up through the large purifier, and which go direct into the floor below.

The COMMITTEE: Have you any knowledge as to the balance of discomfort or the balance of injury resulting from the difference between 20 and 40 grains of sulphur?

Witness: Not to give it you in quantity. I have, however, this knowledge, that occasionally the gas in my house is extremely unpleasant when tasted; at other times it is better, and I do not taste that unpleasant flavour; the difference being, as I presume—in fact, as I know from tasting—the difference of sulphur; but how many grains of it are present I cannot tell. My supply is from the Wandsworth Gas Company, but I do not think they are under the Referees. I do not know their maximum, but I may tell you that I will not use gas, on any account, in my sitting-room.

The CHAIRMAN (addressing Sir E. Beckett) said he thought the evidence just given was the most important on behalf of the opponents they had hitherto heard. Mr. Bramwell had formed his opinion and given his evidence very clearly; but he had only formed that opinion from a visit. According to his evidence, the Commercial Gas Company had lately adopted improvements which had practically got rid of the nuisance; but that evidence had not been given by a witness who was present when the most difficult part of the process was being performed, namely, that of opening and cleansing the purifiers; and, therefore, some further evidence ought to be given upon that subject.

Sir E. BECKETT said he had no control over the Commercial Company. How on earth was it likely that he should get witnesses from one gas company in London against another gas company in London. Of course, if the present Bill was passed, they would all come for a relaxation. If the committee thought proper to send for the engineer, it was quite open for them to do so.

The CHAIRMAN: I think it would be as well. It is quite plain that we cannot finish to-day, and, therefore, supposing you failed in changing us from the opinion we mentioned yesterday, and which you understand was entirely a suggestion, it will then be necessary to go into the financial question, which no doubt will be a difficult matter. It would not be possible to conclude the case to-day entirely, under those circumstances.

After some conversation, and the committee having deliberated,

The CHAIRMAN said it was not only the evidence of the gas engineer, but the learned counsel would probably be able to call some of the residents in the neighbourhood of the Commercial Gas-Works, and they could not be supposed to be hostile to the case of the opponents at all, but it was rather throwing too much upon the committee to require them to find out evidence for themselves in support of that view.

Sir E. BECKETT: If you think it convenient to adjourn generally, I do not see any objection.

The CHAIRMAN thought an adjournment was necessary, and therefore he would state the exact position in which the committee found themselves. The question was one entirely of a balance of convenience between that part of the public who as consumers might be supposed to suffer from the greater amount of sulphur present in the gas, supposing the limit were now relaxed at all, while on the other hand there was the injury to that portion of the public who lived in the neighbourhood of the gas-works where the lime process of purification took place. Of course a great deal in the decision or in the estimate of the balance of convenience must turn upon whether it was possible, by greater care and attention, to diminish or entirely remove the nuisance created by the lime purifying process. The case made by the promoters was that there was not in existence at present, or known, any means of using lime for the purpose of purifying those various compounds out of gas which could successfully be adopted, but the committee had just heard of a process or a practice in using the lime purification which produced a great degree of purity, and at the same time was innocuous. That

was an exceedingly important circumstance, especially as the experiment was conducted under all the conditions under which it would have to be carried out, if adopted by the gas company at present before the committee. He (the chairman) thought Sir E. Beckett would see that it would be very satisfactory, before they arrived at a final decision, to have that case as fully explained, and as completely before the committee, as possible, both as regarded the process which was adopted by the Commercial Gas Company, and also as regarded the effect upon the neighbourhood—as to whether, in fact, when the purifiers were opened there was that nuisance created. They would, therefore, adjourn until the following Tuesday fortnight.

TUESDAY, JUNE 5.

Sir E. BECKETT said the committee would recollect that he had stated he did not expect that he should find Mr. Jones a very willing witness against his brethren of the London gas companies; that guess had been verified, and certainly he should not take the responsibility of calling him, although it was open to the committee to call him if they thought proper. There was one thing, however, which had been done. In consequence of the Paris evidence, two or three gentlemen had been sent over to Paris to analyze the gas there, and they would give the result of that analysis.

Mr. *Charles Heisch* recalled, and examined by Sir E. BECKETT.

During the holidays I have been over to Paris with Mr. Wigner and Mr. Shuter. We visited several places there, and tested the gas. With respect to sulphur, on the 22nd of May I found that the gas in Paris, at the Cité du Retiro, Rue du Faubourg St. Honoré, where I had a room placed at my disposal, contained 15·6 grains in the 100 cubic feet. On the 23rd I again tested at the same place. Those tests extended pretty nearly over the whole day, so as to get a fair average, and the gas contained 15·34 grains; and on the 24th at the same place it was 15·12 grains. I also tested on the other side of the Seine, at the Boulevard Mont-Parnasse, and found the sulphur to be 11·5 grains I took my own apparatus, which was tested immediately before we went, and immediately after we came back, and we found it quite correct.

Cross-examined by Mr. POPE: I did not visit the gas-works, and do not know what process of purification they were employing or what coal they were using.

Re-examined by Sir E BECKETT: I agree with the French witnesses that there was no nuisance at all.

By the COMMITTEE: Our tests were made with the Referees apparatus, just as used in our official testing-stations.

Mr. *G. W. Wigner* recalled, and examined by Sir E. BECKETT.

I made the tests in Paris conjointly with Mr. Heisch, and I also analyzed the liquor which was brought home for that purpose independently of him, and our results agree.

Sir E. BECKETT said that was all the evidence he proposed to trouble the committee with.

Mr. POPE said that Mr. Jones, of the Commercial Gas-Works, was in attendance.

The committee-room was ordered to be cleared. On the counsel and parties being called in,

The CHAIRMAN said: We think it as well to call the manager of the Commercial Gas-Works before Sir E. Beckett addresses the committee.

Mr. *Robert Jones*, examined by the COMMITTEE.

I am not called by any gentlemen on the opposite side of the table, and I wish it to be understood that I am here alone in deference to the wishes of the committee. I have read Mr. Bramwell's evidence, and, so far as his description of the machinery goes, and the manner of our dealing with the lime, it is quite correct; but he was not correct in saying that we were able to reduce the bisulphide of carbon to 13 grains without creating to some

extent an offensive effluvia. The night before Mr. Bramwell's visit the return from the tester of our district gave me an impurity of bisulphide of carbon of 13 grains; but Mr. Bramwell did not see any of the purifiers opened, nor did he see the process of discharging. We had worked for something like two months, preceding the time of Mr. Bramwell's visit, at an average of 13½ grains, and, therefore, so far, he was right about the degree of purity.

The COMMITTEE: As to the possibility of avoiding a nuisance?

Witness: Whilst discharging our purifiers, with that degree of purity of bisulphide of carbon, we had offensive smells at the works; it did not go much beyond the works, but we were complained of by our officers situate some distance from the site of the purifiers. It was impossible for us, with the lime in the state of sulphide of calcium, to have avoided it. We have taken every possible care to discharge the vessels and to carry away the lime without causing any nuisance to the neighbourhood. We have been able to effect a very great deal by the care we have bestowed upon it, but it has been impossible to prevent the smell travelling some distance. Those [pointing to the plan] are the purifiers that we are dealing with, and here, I have often had complaints from the officers—from the secretary especially—that they had a very foul smell in their offices which are situated about 220 yards from the purifiers. Mr. Bramwell's visit was on the 25th of April, and about that time the bisulphide of carbon was 12·7 grains, but owing to the smell being greatly complained of in our offices, I ran the purifiers longer, with a view and a desire to carbonate the lime, and so to destroy that offensive smell. Upon the 26th of April the bisulphide of carbon went up to 14·8, and so it went up constantly until we got to 16·8, 18·2, and 24 grains. Upon the 4th of May it reached 29·3, and upon the 5th to 30 grains; but when we reached that far, I ordered my people to stop that purifier, and to discharge it; and when I saw the lime it was much less offensive than the lime which gave us the results of 12 and 13 grains. It then went down from 30 to 22 upon the 7th, and again upon the 8th to 13·9; and since that time I have been keeping it at from 12 to 11 and 10.

The COMMITTEE: As we understand your evidence, it is this: You have discharged purifiers with a low amount of sulphur, and you have had occasional complaints from your servants, and from nobody else, that there came a foul smell when the purifiers were opened?

Witness: Yes.

Then Mr. Bramwell came on the 25th of April, and his visit was followed by further complaints from your men, which led you to relax the purity which you had previously had. You approached, I think you said, 30 grains, and then discharged the purifier. Was there no complaint made then?—No. When we had got up to 30 grains I ordered the purifiers to be discharged, and the lime was almost innocuous. Some parts of it were wet, and some parts of it were dry, but it had assumed another colour entirely. That was the colour of the lime from a vessel that we discharged on Saturday last [exhibiting a bottle]; the colour of the lime that we discharged on the 5th of May was much lighter; in fact, it had almost come back to its original colour. We could scarcely trace the dark appearance it presents here.

Was the lime equally noxious, the part of it that was dry and the part of it that was wet?—No; I could have stood over it without any inconvenience whatever whilst it was being loaded into carts to be taken away. The lime is not in a very moist state when taken out at any time. Some portions are a little moist; but the major part is dry. The wet lime is the most offensive in smell. There is no greater difficulty in discharging it in a dry state than in a wet state. When I speak of a wet state, I mean a semi-sticky state. I do not think it would be possible to discharge it always in that dry state if we take out the bisulphide of carbon to the extent that we have been doing. Our present maximum is given by the Referees as 30 grains, but that was because we had not our purifiers complete when they made the test. Our purifiers are within a roofed-in building with certain openings to give the men light, and also to give them an amount of air. I put them into those buildings with the intention of confining the smell as much as possible to our own premises, and to some extent it

has had that effect. There is a double roof to the building, and in each of the roofs we have six ventilators, three on each roof.

Then the fact is that you have not any great complaint, upon that particular ground, from the men working?—Yes, we have indeed; and the men themselves, since we have been using lime, have applied to me for an increase of wages, and for spectacles, with a view to prevent their eyes being attacked.

Would it not, so far as it is disagreeable for the men, be mitigated if you had a chimey sufficiently tall to create a draught and ventilate the building?—I think not, because we have openings in the walls as well, with ventilators in the roof, so that there is no complaint at all of want of ventilation in the house.

The committee wish to understand how far you question the statement of Mr. Bramwell, which was very much in favour of the way in which the whole of the operations were conducted at your works?—Mr. Bramwell stated everything correctly, except the fact that he met nothing disagreeable himself when he was there, simply because we were not discharging a purifier at that time, and the barge lying near to the works, which was loaded then with the spent lime, was covered over very closely with tarpaulin. At no time, when the works were at rest in that way, would it be possible for you to say that there was a disagreeable odour or smell about them.

Were the complaints as serious when you were working at 17 as when you were working at 8 grains?—No; and that was the reason I gave the order. I ran my purifiers longer, with a view of carbonating the lime and driving the sulphur out; and during that time, whilst we were getting on up to 30 grains, and when we discharged the purifier that had worked up to that, and I had reached my maximum, then the lime came out, and it was in a condition that not many people would notice.

Does not the result depend very much upon the amount of purification governed by the amount of gas you have to produce, having regard to the size of your purifiers and the number of them, and the facilities, and space, and so on, that you have about you?—In my case, my arrangement of purifiers has been a very recent one, and I have plenty of means to deal with the summer and spring and autumn make. I have another large set of purifiers that I am going to bring into action for the winter. Complaints could not be made against the Commercial Gas-Works, that we had not space or capacity; but notwithstanding that I get the nuisance, if I may be allowed to call it so, although I dislike the word exceedingly.

Do you have any complaints in the neighbourhood?—I had a complaint from the surveyor of the district within the last week, but I do not desire that that should go forward, because it is filling people's mouths out of my own, and they will judge me out of my own mouth.

Examination continued: That which I did was with a view, if possible (and without any reference to my being here to-day at all, for I had no idea that I was going to be placed in this dilemma) of carbonating the lime; and when the lime is carbonated, and the sulphur driven off by the carbonic acid, then it comes out almost innocuous. The longer you run the purifier the more free it is from foul smells, but the gas becomes more impure, of course; there is a greater amount of bisulphide of carbon in the gas.

The Committee: Does it depend upon running the purifier so many days, or upon opening the purifier after a longer interval?

Witness: Upon running it so many days.

Might you not cease to use the purifier as a purifier, and then not open it for some number of days?—It would make very little difference indeed if we were to take the cover off within a few minutes after the purifier is exhausted. By watching to see what quantity of bisulphide of carbon is left in the purifier after it has ceased its operation, then we might lift the lid either within five minutes or after 24 hours; it would make no difference in the state of the lime. Our purifiers are very large, and we are now only discharging one a week.

Supposing you used it for a week, and did not discharge it till the end of the second week—not using it in the second week, but simply keeping the lime there—would not the nature of the lime be so changed by that as to diminish the nuisance resulting from cleaning it out?—Not materially,

I think; besides, we could not spare a purifier for so long as a week. The men have to prepare one after the other; but, notwithstanding that, I believe it would make very little difference indeed.

Before you opened the purifier, had you ventilated it according to the process pursued at Fulham, at Mr. Vernon Harcourt's suggestion?—I do not know the process at all.

The CHAIRMAN: I was at the Fulham works yesterday, and saw a purifier opened, and the whole process of purification gone through from beginning to end. The purifier had been ventilated before it was opened, and when it was opened the lime was in a very dry state. There was a great quantity of sulphur through it, but it had been ventilated, and certainly I could hardly detect any smell at all, though I stood directly where there was a strong breeze, and my coat was covered with this dust. The effect of the ventilation had been, that when the purifier-lid was lifted, of course, there was a slight and rather a disagreeable smell, but none after the purifier-lid was first lifted; and as the three different layers were dug off there was not any serious smell, either within 5 yards, or 20 yards, or 100 yards of the place. Now, do you think that, if you had adopted the plan of ventilating for a certain time—not as long as to run any risk of combustion, or to produce any injury to the purifier—before you opened it you could have avoided the smell at your works, as I saw it avoided at Fulham?

Witness: I have had no experience of that description at all; but, consulting my own feelings, and seeing that this matter is much in the hands of the workmen, I should have some little terror about it. I think it possibly would be successful, and the only fear I should have would be the danger attending it.

Sir EDMUND BECKETT, in commencing his remarks on behalf of the opponents of the Bill, said the present case reminded him a good deal of the course taken on the first general gas Bill relating to the Metropolis in the year 1860. There, as here, different impressions seemed to have arisen at different parts of the case, and the committee expressed opinions which they very candidly allowed to be modified by what took place afterwards, and when they came to a matter of difficult science like this, it was not at all unnatural that that should be the case. He remembered in 1860, on a certain Friday, the committee gave expression to some opinions which delighted the gas companies very much, but on the following Monday morning, after some further evidence, the views of the committee were materially altered, and the result was that the gas Act of 1860 was passed, which was considered then a sort of charter for the public against the gas companies on the one hand, and on the other hand a sort of charter for the gas companies themselves. But some difficulties were found afterwards by those representing the public; and the consequence was that attempts were made, partly by the Board of Trade, partly by the Corporation of London, and partly by the Metropolitan Board of Works, to obtain some modification of the Act of 1860; and after three years discussion in Parliament—namely, 1866, 1867, and 1868—another Act was passed by a committee, presided over for two years running by Mr. Cardwell. This constituted a sort of second charter or settlement of terms between the companies and the public, as represented by the Corporation and the Metropolitan Board of Works. It was necessary to remind the committee that part of the arrangement of 1868 dealt with the sulphur question in a way suggested by the companies themselves; and, as might be remembered, they objected to the enactments of 1860, by which a hard and fast line of 20 grains of sulphur was prescribed, and they suggested Referees. The committee of 1867 and 1868 approved of the suggestion, and the clause appointing the Referees was drawn by the ablest hand they ever had there at drawing clauses—namely, his learned friend, Mr. Burke—so that it could hardly be said that the Referee clause of 1868, if it had any fault at all, erred in the direction of being unfavourable to the gas companies. In point of fact, as appeared by Mr. Evans—the leader of the battle on the other side—the companies thought it an extremely good clause; and it was only because it had not turned out as good as was expected that they were now trying to alter it. Having entered into an agreement with the Metropolitan Board and the Corporation as lately as 1876, it would be an act of rather rapid retrogression

to immediately afterwards try to alter the arrangement with which they were satisfied at the end of the previous year. The course of legislation throughout had been an attempt on the part of Parliament and of the public bodies to keep down the quantity of sulphur in the gas to as low a minimum as possible, and it would require very much stronger evidence than any which had been given to induce the committee to pass a Bill of that kind, if there were nothing else in it. The company protested that they did not mean to throw any reflections upon the Referees, but they had proceeded throughout to throw as much odium as they could on them, and had applied to them a great variety of epithets. One or two gentlemen on the other side charged them with incompetence, and Mr. Michael cross-examined one of the Referees at great length to prove that they had no practical experience, while Mr. Evans, who did not stick at trifles, took the bull by the horns, and said if they had only acted conscientiously he could get on pretty well, but they did not. Another witness on the other side boldly said they were unfit for their place; indeed, from the beginning to the end of the case, the counsel and pretty nearly all the witnesses who had any excuse for so doing, used language reflecting upon the Referees. It did not appear to have occurred to the company that if the Referees were inefficient, unqualified, unfit for their place, and did not act conscientiously, that the proper thing for them would have been to go to the Board of Trade and say, "Gentlemen, you have appointed officials having all these disqualifications, but you are not bound to reappoint them. Pray do not reappoint these three gentlemen; they are unconscientious, and all these things." There was not a single thing which the company had stated to induce the committee to pass their Bill that they could not have stated to the Board of Trade, and which that Board could not have dealt with. Had there been any proposal to change the Referees? The various public bodies interested had not insisted that the same Referees should be appointed; and if Mr. Evans would tell his story to the Board of Trade, they are bound to assume that the Board of Trade, being a judicial body, would appoint either one or two fresh Referees, or give some chance of their bringing their case before somebody else. A singular thing was, that the Referees should have been satisfactory to the companies during the period when Mr. Evans himself was a Referee, because he contrived so to modify their views that they did not stipulate for anything lower than 40 grains. How Mr. Evans came to be appointed a Referee he (Sir E. Beckett) did not know. He seemed to be not at all the kind of man; but there were underground ways of doing things which gas people knew as well as other people. They got him appointed, but naturally the appointment made such a row that he was obliged to retire, and as soon as he retired a new state of things arose. Then they got "unconscientious Referees," who began to behave ill when they began to carry out the Act which they were intended to carry out, instead of being bullied out of it by a gentleman like Mr. Evans. He was saying that they began to complain, but they did not begin to complain till last year. They took care to get all their money first; they got all their pecuniary arrangements ratified by Parliament, they got their amalgamation with the Imperial, and a variety of other small companies; and they got the price of gas sanctioned by Mr. Forster's committee on the express footing that the extra purification involved a greater price. It was true the company said they were willing to have that matter re-discussed, but the public bodies were not going to hamper themselves as to future proceedings by discussing any detail of that kind. They insisted upon the bargain made as lately as last year, and were not going to discuss financial details. The correspondence showed that the whole matter was in the nature of a personal fight between Mr. Evans and the present Referees. Mr. Evans, indeed, confessed that he could not bully the Referees into submitting to him, as he had succeeded in bullying or persuading them when he was one himself. It was nothing but a personal dispute, between Mr. Evans and those Referees, who was to get the best of it, and if they could carry out of that committee any Bill substantially modifying the present state of things, even to the extent of the 30 or 33 grains, Mr. Evans would say, "I have licked the Referees—I told them I would, and I have." The question was, whether Parliament would help him in doing that.

The learned counsel then read several extracts from the evidence given by Mr. Evans, and contended that that evidence so bristled with contradictions that it could not be opened anywhere and contrasted with the statements of the Referees, as to matters of fact, not opinion, without seeing that Mr. Evans was inventing a case for the Bill. It was his Bill throughout, and was a personal fight between him and the Referees. Then they had another excuse, which was inspired by Mr. Evans. The great difficulty which had come upon them quite suddenly and unexpectedly had been the amalgamation with the Imperial. His learned friend said it was the *damnosa hereditas* of the Imperial which had brought it upon them. Why did they buy the Imperial? They bought at the critical period between 1875 and 1876; that was, they got all their financial arrangements through Mr. Forster's committee, and power to divide, not only 10 per cent., but as much more as they could consistently with the sliding scale; and although the sliding scale was complained of at the time, yet Mr. Evans said it had been a very profitable thing for them, in consequence of the fall in the price of coal. Having got it, however, and having waited to see the result of it, they then bought up the Imperial to please themselves, and then they used the Imperial as the excuse for getting rid of the obligation to reduce the sulphur, because it would have beaten even Mr. Evans to find an excuse for getting the free and unadulterated Chartered Company out of that obligation. He knew he would be met with the fact that he had told every committee in Parliament that at Beckton they had the means of making all the gas that they possibly could require out of London, in a place where stinks were indigenous, and therefore the *damnosa hereditas* was necessary. The attention of the committee was seriously asked to the question whether the time had not arrived when the manufacture of gas ought to be turned out of London altogether; and if it should be the case that the company could not make pure gas without creating a nuisance, the true answer to that would be, "Very well, then; make none in London. Make it all at Beckton and at Bow. You have said over and over again that you can; now go and do it,"—and would not that be an enormous benefit to London? So much for the *damnosa hereditas* as regarded the Chartered Company. But the Imperial Company had an existence long before the Chartered Company thought of this scheme, and had been purifying gas since 1860, at any rate, down to 20 grains, and 25 grains, and so on. The Imperial never found any difficulty, and they had not been a company particularly given to submitting to parliamentary requirements. As regarded the question of purification, Mr. Evans said: "We should, if we were allowed to go back to the oxide of iron again, use a little lime for the carbonic acid." If they were allowed to go back! Who ever stopped him using the oxide of iron? It was utter recklessness on the part of Mr. Evans to say that they were obliged to give up using oxide of iron. What obliged them? They might choose to give it up because it would cost them more money to use oxide of iron and lime, but that was no business of any one else's. Surely people who had a ten per cent. dividend, and practically the means of earning as much more as they liked on the sliding scale, were not the people to talk about their poverty. Why ought they not to be called upon to use the best possible means? One of their best witnesses—Dr. Tidy—said he would not regard it as a question of money. Unless he (Sir E. Beckett) was greatly wrong, Mr. Evans seemed to have entirely failed in the basis he laid for the present case. His basis was, that he was obliged to give up using that very thing which another engineer of equal experience said he did use, and used with success. What Mr. Anderson could do at Dover, at Cork, at Waterford, and at some other places, though they were not so large as London, of course Mr. Evans could do; and with regard to the difficulty of getting rid of the lime, that was obviously a mere question of money. The Essex Marshes were big enough and low enough to be able to receive all Mr. Evans's lime if he chose to send it there. At the same time, two or three witnesses upon the other side said they believed he used about five times as much lime as he need. They might be right, or they might be wrong, or the truth might lie between them; but, whether it was much or little, Mr. Evans must pay for taking it away if he was encumbered with it. Another question was whether Mr. Evans pointed out that difficulty in 1866. Could any human

being believe that it came upon him by surprise, and that it was any part of the *damnosa hereditas*, because the lime he had received with that *damnosa hereditas* was lime made at Fulham, St. Pancras, and other places, and had nothing to do with the lime at Beckton? He knew that in 1875, in 1868, and in 1867, and it was really only another trumped-up excuse. Of course it was necessary to his case that Mr. Evans should make out that the Corporation of London and all the chemists upon their side, and even one or two upon his own side, were entirely wrong in saying that there was any importance in getting rid of the sulphur. When it was necessary, he was chemist and everything else, but Mr. Evans denied that there was anything in the sulphuric acid story, although it was proved most distinctly by chemists without end that the sulphur left in the gas, by the aid of the oxygen in the air, multiplied itself into three times its bulk of sulphuric acid; and then at some place or other Mr. Evans said that that was all a delusion, and that the complaints were "rubbish;" but Dr. Tidy, one of the most distinguished witnesses on the side of the gas company, clearly stated that he did not agree with Mr. Evans in saying that the public apprehension about sulphur was a delusion. All through his evidence he said that in the present state of science he thought they ought to be allowed as much as 35 grains, but that if he could see his way to it being reduced even to 10 he would do so. There was also the evidence given upon the Crystal Palace Bill by Professor Barff, Dr. Frankland, Mr. Pattinson, and others; and, with all that staring the committee in the face, what view of the case were they going to take? It was a fairly open question how much sulphur could be got out without making a nuisance; but to talk about the sulphur being no nuisance was mere recklessness of swearing, and they would have to consider how far that reduction, if at all, could take place, and ought to take place. The Metropolitan Board and the Corporation, as representing the public, were not fighting for mere victory; they were fighting because sulphur was a bad thing, and ought to be got rid of, if it could be got rid of without inflicting some corresponding or greater nuisance. He (Sir E. Beckett) did not know how it would be possible, consistent with logic, after having rejected the Crystal Palace Bill, which contained an absolute limit of 20 grains, to pass the present Bill with any modification, giving the Chartered Company something more than 20 grains, whether it be 30, 33, 35, or anything else. It would be a strong result for the company to obtain; but he thought Parliament would have sufficient regard to its own logic not to attend to that, even if the Board of Trade were satisfied. People talked of the Board of Trade as if they were a sort of incarnation of wisdom; but they were not always found to be so. The Board of Trade did not represent the people of London, but the Metropolitan Board and the Corporation of London did, and they flattered themselves that they could judge just as well as the Board of Trade. The committee knew ten times more about it than the board could do, as they had not heard the evidence.

The CHAIRMAN: I am afraid you must not shift the responsibility in that way; the suggestion, be it good or bad, is not in any way referable to the Board of Trade. I thought it as well to consult them as to whether they saw any difficulty in working it out in case it should be adopted, but the responsibility for the suggestion rests entirely with the committee, and I should say more properly with the chairman, and therefore I think you may leave the Board of Trade alone at present.

Sir E. BECKETT said he thought it would not be respectful if he had not said something about them, as many people would rather be abused than not noticed. He hoped the chairman would take the responsibility upon himself, and not think of being influenced by anybody in the Board of Trade. Another suggestion had been made by the committee—viz., that there should be a kind of substitute for the Referees—somebody to be appointed by the Board of Trade to inquire from time to time, and have experiments made at the gas-works; but he would like to know how that person, or those persons, would differ in substance from the Referees, excepting, as he understood, those persons would not be able to act except upon experiments conducted for them by Mr. Evans, who would, doubtless, conduct them with the utmost sincerity; but it must be remembered what Mr. Bramwell's view was of what his position would be if he were

a Referee appointed under those conditions. He (Sir E. Beckett), speaking again for the public, entirely dissented from having any persons appointed to judge their rights and interests, upon the condition of being obliged to carry on experiments by the aid of their enemies, because they would have an interest in doing as little as they could, and getting as much as they could; in other words, he required, on behalf of the Referees, the most unlimited discretion. Turning to the question of nuisance, as regarded actual nuisance, he admitted there was plenty, but as to the necessary nuisance he did not admit so much. It was very true that evidence on behalf of a gas company was necessarily negative evidence and, therefore, inconclusive, but it was not the less negative evidence, because it was necessarily negative. Negative evidence was very good till it was either helped or contradicted by positive evidence, but when it was met by positive evidence it did not go for much. If there was a distinct proof of one single gas-work in the world where the purity was kept down to anything like 20 grains, with the same kind of coal, without creating a nuisance, that would answer the evidence of every gas company in London, and in every large town in England; but, strange to say, there was none from any other town to the effect that they could not prevent the nuisance. They had had the evidence from the Paris gentlemen about the coal they used—practically it was the same coal as used in London at the present time—and they kept their sulphur down to 15 grains, and there was no nuisance. The Referees had made a very great mistake in ever trying to teach the gas companies how to do it. If he (Sir E. Beckett) were a Gas Referee, and they asked him, "What do you want done?" he should reply, "Want done? I want the sulphur kept out." "How are we to do it?"—"Go and find out at Nottingham, Leeds, Pontefract, Dover, Newcastle, and all these places, what they are doing; do not ask me to teach you your work. I am here to test what you do, and I am here to learn as well as I can, with such information as I can get, whether the sulphur can be kept out to this extent." The learned counsel read several extracts from Dr. Frankland's evidence on the Crystal Palace District Gas Bill, and contended that that was chemical evidence of the highest eminence, in confirmation of Mr. Anderson's practical evidence, and he thought, with those two things together, there could be no doubt that Mr. Evans was as wrong as he possibly could be, not merely practically but scientifically, in talking about his being obliged to give up the use of oxide for the lime. It was very likely that a good many of the smells which had been mentioned were not pure sulphur smells, the public nose was not very sensitive as to smell, and if they smelt anything unpleasant they would probably conclude it was the sulphur in the lime, because they had heard that the sulphur did cause a nuisance. The committee also had the evidence of Mr. Loam, who stated that at Nottingham they principally used lime for purifying, although they used oxide of iron in the catch purifiers. He also stated that the farmers came with their carts and took the lime away as they liked, but they had no complaint as to nuisance. That led to another topic. It was thought worth while by one of the learned counsel to ask this question: "In 1873, when the Corporation and the Board of Works brought in a Bill conjointly for buying up the London Gas Companies, did they put in any limitation as to the purity from sulphur?" and the answer was "No" It was thought a great triumph to get that answer. But why need corporations put restrictions upon themselves? There was the Corporation of Nottingham, who had the gas-works, and they had no restrictions, yet they reduced their sulphur as low as they could, because, of course, the public required it. It was really idle to ask a question of that sort. Dr. Pole, one of the Referees, also gave his positive knowledge as a reason for requiring what he did require of the London Gas Companies. He said that he visited Edinburgh, and found that lime was used entirely there; that the works were in one of the best parts of the town,—between Carlton Hill and Canongate—and that he went carefully over them, and spent some days with the manager. He was living in Princes Street during the time when the wind was blowing from the works towards the hotel, and there was no nuisance, and there was nothing in the gas which gave him reason to suppose that it would be impossible to purify it by lime. Mr. Anderson likewise said that he had

been engaged for 30 years in managing gas-works, and he mentioned the things that he had used, and also how he used the lime. [Evidence read.] The committee had thus three distinct processes before them: they had Dr. Frankland's statement that at Manchester they did it without any lime at all, or very little; Mr. Anderson saying that he used both lime and oxide; and Mr. Loam's evidence that he did it with lime; so that there were three different ways of treating it, and all successfully. Mr. Heisch, who was examined in the Crystal Palace case, also stated that the Phœnix Gas Company had, since 1860, complied with the 20 grains condition, as a rule, without creating a nuisance. There was also the clerk of the Lewisham Board, a gentleman of the name of Edwards, who said the same thing; therefore there was actually a London Company complying with the 20 grains condition, and doing it perfectly satisfactorily. There was also the case of Bow, about which Mr. Evans stated that the lime, if exposed to the air, became pure after a certain time, and had not much smell. A reference to Beckton was likewise made somewhere in Mr. Bramwell's evidence, if not in others.

Mr. POPE: Mr. Bramwell was never there.

Sir E. BECKETT said that Mr. Bramwell stated that he had been to Beckton, to Bow Common, and to a good many other works. He also stated that he had seen the process carried out at Beckton without a nuisance.

Mr. POPE: He never saw the process at Beckton in his life. I say that it is not so.

Sir E. BECKETT said that Mr. Bramwell was asked, "Supposing Beckton were in the middle of London, would the lime be a nuisance then?—A. The whole works would be a nuisance. Q. Would not the lime process be a nuisance?—A. I do not believe it need be." Nothing more need be said about Beckton, and, as regarded Bow, Mr. Wigner, as well as Mr. Evans, said there was no nuisance there. As regarded Fulham, it was certainly open to the remark that Dr. Tyndall made, that, when he and his wife were there, and they both had very good noses, although there was every possible means to induce the laws of nature to behave decently, the place would not stink. Then there was Mr. George Livesey, of the South Metropolitan Company, who was not the man to blow his own trumpet, but he told the committee what he managed to do there. He stated that the average result of the testings for the quarter ending Dec. 31, 1876, had been only 17·7 grains in 100 cubic feet. He also stated that in December, 1875, his gas was ten times over the limit of 25 grains allowed during the six winter months, and in the month of January it was ten times in excess; but from the end of January, 1876, up to the end of February of this year, there was not a single excess, and then the excesses came on, although why they came on he never could find out. As regarded Mr. Jones, he (Sir E. Beckett) was glad to hear his evidence, and particularly glad to find that he on no substantial point contradicted Mr. Bramwell, although he could not help thinking that Mr. Bramwell's statement as to what had been done with the purifier immediately before he was there must, from the nature of things, be right rather than Mr. Jones recollection and thinking. Mr. Hawksley had mentioned another mode of getting rid of the nuisance; at any rate, he said very positively that it could be done, not only from his Nottingham experience, but from other circumstances. His friend, Mr. Richards, who cross-examined Mr. Hawksley, thought the best thing he could do would be to throw a little odium upon that gentleman by suggesting that if the company had come to him first they could have got his evidence; but he (Sir E. Beckett) had a very strong suspicion that there had been some very good reason why they did not call Mr. Hawksley, because it would be the most natural thing that he should be the first person they would go to when they wanted a scientific witness. In 1867 Mr. Hawksley was on the side of the gas companies, and therefore anxious to say everything he could for them; but, in the course of his examination, he said that he thought a better mode of purification had been discovered than had at that time been spoken of, and that was, to continue the use of oxide of iron for taking out the sulphuretted hydrogen, and then only using the lime for the purpose of taking out the remaining bisulphide. His opinion was that by

the combination of the two processes, the works could be carried on where they were, but that the effect of the double process meant a cost of about 1d. per 1000 feet more. That was a tolerably good reason why the companies did not ask Mr. Hawksley to give evidence for them; but they might as well have had the decency to look at that matter before they made that charge. Having gone through those different descriptions of the modes of doing this business, he (Sir E. Beckett) thought that if there had been only one instead of about a dozen, that would be a decisive answer to the allegation on the other side that sulphur down to 20 grains could not be got out without creating a considerable nuisance. It was plain that it could, and it was also plain that one of their most valuable witnesses, Dr. Tidy, was convinced that it ought to be done, if it could, though he did not know the means by which it could be done, although other people did. He made a suggestion which appeared to be a very pregnant one. He said they ought to pay for having sulphur in, which probably meant that if they were to be let off a certain amount of sulphur, they should pay some kind of penalty for every 5 grains so let off. Mr. Vernon Harcourt also said he would rather pay twopence more and have the gas pure. There had not been a single scientific witness worth talking about who had attempted to prove that there was any real difficulty in complying with the Act of 1860, much more with the requisitions of the Referees, which were at any rate five degrees easier in winter, and might also be made five degrees easier next winter if they could convince either the present or some other Referees that they ought to be relaxed to that extent; but, on behalf of the two public bodies, he (Sir E. Beckett) protested entirely against that very recent bargain, which was a continuation of a previous bargain, being relaxed now, simply and solely at the instance of Mr. Evans and the Chartered Company.

Mr. ROUND said he did not wish to make any remarks in a partisan spirit, because the Board of Trade, by whose instructions he appeared, desired to express no opinion whatever as to whether it was politic or not to do that which the gas company were asking the committee to do. But at the same time, inasmuch as the Bill, if it passed, would withdraw from the jurisdicton of the Referees the power vested in them of determining what amount of impurity in the form of sulphur should be allowed in the gas, he thought it was not otherwise than relevant to the question to see how far the Referees had discharged that duty which Parliament had imposed upon them in reference to the legislation affecting gas. He thought there could be but one opinion in the minds of all who had followed this inquiry, that those gentlemen had done themselves infinite credit by the way in which they had discharged their duties in conformity with their instructions, and with the spirit of the Act of Parliament. He thought also that there could be no two opinions that they had an extremely delicate and difficult position to fill, and a somewhat invidious one, which they had succeded in discharging to the utmost reasonable satisfaction of everybody who had had an interest in the way in which their duties were being discharged. It was quite clear that the Acts of Parliament under which they had jurisdiction provided for more than the entire removal of sulphuretted hydrogen, and that idea could not be better expressed than in the way those gentlemen had themselves expressed it in their letter of March 5, 1877, in which they said that "it is clearly the intention of the Acts now in force, that the gas company shall be requiried to reduce the amount of sulphur in all forms, as well as wholly to remove sulphuretted hydrogen. The question we have had to decide is, how far this amount can be reduced, considering what is reasonable, and especially the necessity of avoiding nuisance." That was the interpretation—and a correct one—which they had put upon the Act imposing those duties upon them, and it also put them at once right as to the limits within which they had conducted their inquiries. He was perfectly certain that those gentlemen did not require any vindication on his part, for they had amply vindicated their appointment by the Board of Trade as the most competent men that could have been found to undertake the duties imposed upon them; but there had been one or two remarks thrown out by them which ought to have been met in a different way by the promoters of the Bill, and they were mentioned with a view to the justification of the

course which the Referees had adopted. Those gentlemen, in the letter referred to, pointed out what, in their opinion, had been the cause of the increase of nuisance which had arisen within the previous six months, although the proportion of sulphur—namely, 20 to 25 grains—had been in operation for four years, and they put forward a very strong opinion upon that point. They found there was no uniformity of system at the different works of the company; they found that what was considered good at one works was not carried out at other works, and it took a two-fold form—first of all, there was the process of opening the purifier, and the mode in which they ventilated the lime, and endeavoured to get the gas free from those impurities. The next thing, distinct altogether from that, was the way in which they removed the obnoxious lime after it had answered (or was supposed to have answered) its purpose. They found that the purifiers were under cover at Kensal Green, Pimlico, and at Beckton, but that they were not under cover at Fulham, Bromley, and at Haggerston. The inference to be drawn from that was, that if it was a good thing to put them under cover at one place, it would be at all, and the committee were doubtless impressed, to a certain extent, with the view that it would be better that the purifiers should be under cover. Had the promoters proved that that statement was wrong, or had they called any gentleman who could contravert the opinion which the Referees had expressed? Again, the process of removal varied. Fulham, which was deficient in one respect—namely, that the purifiers were not under cover—contrasted favourably with other works as regarded the removal process. The Referees naturally said, "Why can you not take the same precautions at other places with regard to the removal of your refuse as at Fulham?" And it might have been expected that the gas company would have shown why they did not; but they had done nothing of the kind. There was another point, which Mr. Vernon Harcourt mentioned, but which had not been alluded to again in the inquiry, and to which, in justification of these gentlemen, the attention of the committee should be drawn—viz., that they were not to act as the companies engineers, but to point out to them that, if certain things were not done, the Referees had a right to expect the companies to show how far that which they had done was right; but there had been no such evidence. Mr. Harcourt stated he tried an experiment which was ultimately terminated, not because the process failed, but because of the accident which had happened to the apparatus. Then he said, "My belief is, that if the company were willing to make a trial of this process it would be practicable to overcome the engineering difficulty, but more than I have done in the matter I cannot do; it must rest with the company to try it or not." Subsequently a question was put by the chairman: "You think that it ought to have been followed up?" To which Mr. Harcourt replied: "I think it is an alternative process. I have already expressed my belief that this process of purification by lime is practicable. I think that, with those improvements which Mr. Evans has introduced, it may be continued without nuisance; it accomplishes as complete a purification as the heating process would accomplish." He (Mr. Round) alluded to that part of the evidence more particularly, because it seemed to have been assumed throughout this inquiry that gas could only be purified by lime, and that it necessarily followed that an additional nuisance was created by that lime. The Referees said the alternative process could be adopted, and that they had not advanced anything that was not a practical matter; and if they retired from that room with the impression that nothing they had heard had changed their opinion in any way, it was because the other side had not shown that those testings which had been made from time to time by the Referees had not been fairly carried out. The committee would see how difficult it was for these gentlemen to act if, when going to one work, they found Mr. A. doing one thing, and on going to another work they found Mr. B. doing another, and then on going to another work they found Mr. C. doing a third thing. As they pointed out in one of their letters, they said: "It might naturally be expected that a gas company supplying more than half of London, and having about £7,000,000 of capital, would have some eminent responsible and active head engineer to direct and control their scientific and manufacturing arrangements. But there is no such

officer. Mr. Evans (whose great knowledge, ability, and experience are known to the Board of Trade as well as to ourselves) no longer occupies this position; and the management is in each case left to a local superintendent of the special place of manufacture. We have no reason to doubt the competency of these gentlemen for the positions they hold—indeed, we know some of them to be men of ability—but we notice among them a singular diversity of opinion and practice, and some disinclination, perhaps natural, to cope with a problem new to their experience. They have expressed their readiness to try any suggestions made by us; and we have pointed out some of the more obvious defects in the processes we have seen; but it is not our province to act as the company's engineers or chemical advisers. The absence of any well-qualified technical head with whom we could communicate on the general problem has been a source of continual inconvenience, and we are convinced that if the subject were earnestly taken in hand by a person so qualified, all the difficulties attending it would soon disappear." Upon that he would ask, had there been a single tittle of evidence addressed by the other side why there should not be such an adviser appointed? The Referees having explained in such a lucid and satisfactory manner the way in which they had discharged their duties, he (Mr. Round) felt that it would not be otherwise than becoming in him to point out that the other side had not shown that anything which the Referees had advanced was otherwise than perfectly compatible with what might be done, and that they had discharged their duties in a manner entitling them to credit, and to the great satisfaction of those who appointed them.

The CHAIRMAN: With regard to the remarks you have just made, I would say that, as to the exercise of the discretion vested in the Referees with regard to this question, it is a subject upon which I will express no opinion until the committee deliver their decision upon the whole question before them. As regards their general capacity in fulfilling the office which they hold, that is not a matter into which the committee have any right at all to enter. It would be, I may say, impertinent for them to express any opinion upon that subject; but, so far as regards the manner in which the Referees have given their evidence, I may say, with the concurrence of the others members of the committee I am sure, that it has been entirely frank and satisfactory; and I think, as we asked these gentlemen to attend, not as witnesses upon either one side or the other, but to throw light generally upon the subject, they were quite justified in giving their evidence as they did.

Mr. ROUND: Upon their part I thank you for that expression of opinion.

WEDNESDAY, JUNE 6.

Mr. POPE, in replying upon the whole case, said, he would not follow Sir E. Beckett into the vein of personal observation. It was difficult to recognize his learned friend in his new mantle. They had been accustomed to regard him as the champion of the gas and water companies in Parliament and out of Parliament, in the colums of *The Times*, and in every capacity in which he could bring his versatile genius to bear upon the question; but he had now decently wrapped himself up in the mantle of the Metropolitan Board of Works and the Corporation, although the cloven foot peeped from beneath now and then. His learned friend had hoisted Mr. Evans into a position, with regard to the present question, which must have astonished him. It appeared that the whole case was the invention of Mr. Evans, for the purpose of enabling him to carry on a personal contest between himself and the Referees, and that gentleman had been charged with inaccurate statements and violent language, which should rather have commended him to the attention of his learned friend than have induced him to visit Mr. Evans with his censure. He (Mr. Pope) really thought the best thing he could do was to brush aside all stuff of that kind; and he would again state, as he stated at first, that he did not desire to say anything with regard to the Referees, except to speak of them in terms of the most profound respect. The most which he had said, and the most Mr. Evans had said, though he spoke it in rather plain language, was that the

Act of Parliament provided that one member of that tribunal should have a special qualification and a practical acquaintance with the manufacture and supply of gas; and all that had been said with regard to the eminent gentlemen who had been in the box had been, that it did not at all follow that an eminent chemist, or even a professor of physics, was necessarily practically acquainted with the manufacture and supply of gas. Sir B. Beckett had asked that there should be no change in the legislation either of 1868 or of 1876; and so far as his argument was addressed to that view, he (Mr. Pope) would endeavour to deal with it respectfully and with consideration; but beyond that they seemed to have arrived, by general consent, at some notion of what the real question was they had to discuss, and to try whether it was worth while to insist upon the adoption of the lime process of purification for gas. That was really the simple question, and it was not now made in the interest of the company, but it was a question of the balance of advantage or disadvantage in the interest of the public purely. He was not instructed to urge one argument in the interest of the company upon the score of any expense which such a process might occasion, if it was a necessary thing that the lime process of purification should be adopted; but when the committee came to consider the question as a balance of advantages and disadvantages, they must not look at the suggestions which his learned friend had thrown out, but at the facts as they appeared in the evidence. It was not proposed at present to enter upon the general question of whether the presence of sulphur in gas was or was not absolutely injurious. That was a question upon which opinions differed, and might reasonably differ. Chemists of very great eminence on the one side entertained an opinion which was not shared by chemists of equal eminence on the other; but, in a matter which was at least open to grave doubt, in all probability the benefit of that doubt would be given to the public rather that to the company, however onerous the conditions imposed upon them might be. Therefore, as regarded that condition, the committee would not be asked to affirmatively decide that it was of no consequence to the public whether any sulphur impurity existed in the gas or not. But, in the face of the evidence, he (Mr. Pope) thought he was entitled to ask the committee to come to the conclusion, that it was of very little consequence whether the amount of that impurity should be 20 grains or 40 grains as a maximum; whether the average, so to speak, was from 15 to 17, or from 33 to 35; and he was justified in saying that, because Mr. Harcourt himself very frankly said so too. Mr. Harcourt certainly afterwards stated that it did, in his mind, represent a certain pecuniary value on the article or the commodity which he obtained; and that, if he could get perfectly pure gas for 2d. per 1000 feet more than gas containing sulphur impurities, the tendency of his mind would be to prefer the pure gas at the extra price rather than run the risk of the sulphur. But beyond that Mr. Harcourt did not venture to say; on the contrary, he said that it was at least of very little consequence. The learned counsel read the evidence given by Mr. Harcourt on that point, and said he had done so because it seemed to involve the three concessories upon which the company might found their argument. One was that the mischief which the prescriptive maximum sought to cure, and which the lime process was looked upon as necessary to cure, was one of no great consequence to the consumer. It was not, therefore, the great and mischievous evil which the Metropolitan Board and the Corporation seemed to think, inasmuch as the restrictions or prescriptions were to be reasonable. One of the first elements in the consideration of the reasonableness of a proposal was whether the remedy was commensurate with the mischief, or was larger than was necessary, in order to get rid of that inconvenience. The evil of the presence of 20 grains of sulphur, it had been conceded on the other side, was of no great consequence to the consumer; and it was further conceded that if it should turn out that, in order to obtain an advantage, inevitable mischief was occasioned to the whole public, then the figures need not cost the committee much trouble as to what they should be relaxed to, because the alternative was a maximum of 40 grains; and he (Mr. Pope) might say at once, on the part of the company, that whatever might be the view which the committee ultimately entertained as regarded the progress of invention, as

regarded the adoption of other processes, and as regarded the invention of machinery by which that might be developed or insisted upon, they would be entirely content if, instead of passing the Bill in its integrity, the suggestion which he ventured to throw out at the commencement should meet with their assent—namely, that the maximum, instead of being 20, should be relaxed at present to a maximum of 40, or, if it should be preferred, such an average as that represented; leaving it, of course, in the discretion of the committee to deal with other parts of the case in the manner they sketched out in the suggestions which they laid before the parties previous to Whitsuntide. Sir E. Beckett had contended (and in that seemed to lie one of the fallacies of his argument) that it was the duty of the Referees simply to lay down a sort of canon, with which the companies must comply. In other words, his theory was, that if the Referees came to a conclusion in their own minds that a maximum of 20 grains might be prescribed without nuisance, it was their duty to prescribe that maximum, and leave the companies to carry it out at their peril, and if the lime process would not do it, to find out something that would. That was not the intention of the legislation of 1867 or 1868. What was it that Parliament had said was to be the rule in that matter? Not the will of the Referees; not even the opinion of the Referees, however earnestly and however honestly entertained, but it was: "The Gas Referees shall from time to time ascertain with what degree of purity the said company can reasonably be required;" not "absolutely," but "reasonably." The reasonablenes of the requisition was to be a matter which was to enter into their consideration. Could it be contended that it would be a reasonable thing for a body of gentlemen, who entertained scientific opinions of their own, simply to force those opinions at the peril of the companies, without being able to suggest a mode by which they could be carried out. In the present case there was a remarkable feature—that there had not been a single instance in which the Referees had suggested anything which could be carried out, which had not been carried out by the companies *bonâ fide*, in good faith. Mr. Harcourt had had an opportunity—perhaps not to the fullest extent he would desire, but at all events to a very considerable extent, and at a very large expense—to carry out what appeared to him a hopeful process, but which had not as yet developed itself into a matter of sufficient practical value to enable him to say, "That is a process which I think you ought to adopt, and if you do adopt it you may accomplish this." All that would be reasonable, but in the meantime where were the company? Were they to be subject to an arbitrary hard and fast dictation on the part of the Referees, however competent, when the Act of Parliament said it must be reasonable, and, therefore, not only reasonable with regard to the make and supply of gas, but reasonable also with regard to the make and supply of gas continuously, and without causing a nuisance. It might be true that there had been days on which, say at Fulham, Professor Tyndall, with his excellent organ, and with the assistance of the olfactory sense of the lady who had accepted his name and fortune, had found it difficult to detect the immediate presence of a nuisance there—it might be from the atmospheric condition; it might be because the process had been working perfectly; or it might be from many other circumstances; but what had to be seen was whether the conditions were such that those circumstances and those conditions were continuous and constant. Of course, if an allegation were sustained such as that somewhat heedlessly and incautiously thrown out by Mr. Bramwell, that the processes were purposely made a nuisance, he (Mr. Pope) did not mean to say that that would be a reasonable thing for the company to insist upon as an excuse; but, on the other hand, what was to be looked to, according to legislation, was some process—the lime process, or any other—which could be employed continuously, without at some time or other occasioning a nuisance sufficient to justify the rejection of that process. It must not be a laboratory experiment, but it must be a reasonable process, continuously producing the proper result as a matter of practical manufacture in the hands of ordinary workpeople, and in the condition of an ordinary process, when that process was carried on, on a large scale, for the purpose of the supply of gas to a large

district. That was the meaning of it, and that was the reason why Parliament inserted in the clause empowering the Board of Trade to construct the tribunal, that one of its number should be practically acquainted with the manufacture and supply of gas, not because either Parliament or the companies doubted for one single moment that Mr. Harcourt's knowledge, *quâ* knowledge, was of the highest character, both as regarded gas and as regarded the chemical combinations and results which arose from the manufacture, but because of the difficulties in the practical manufacture which were known only to those who had the management of men and the management of large concerns and operations. Those who had been accustomed to Lancashire and places of that kind, knew many instances in which the most perfect and beautiful laboratory experiments utterly failed when they came to be applied by comparative rule of thumb, and also through the awkwardness of the ordinary workmen employed. Under those circumstances, in what position did matters stand? Was it not demonstrated, as far as evidence could demonstrate it, that, continuously, at all events, the lime process could not be conducted without producing the results of nuisance in the neighbourhood of these works? If that were so, the question seemed to be, was the mischief which was of no great consequence—namely, the presence of 20 grains of sulphur—sufficient to justify the committee in forcing upon the public the lime process of purification? That was the issue they had to decide; and, dealing with the matter logically, there was hardly an escape. He (Mr. Pope) ventured to submit that the view which the committee seemed to entertain (though, of course, they pledged themselves to nothing) before Whitsuntide, was one which might well be sustained now, notwithstanding all the suggestions of his learned friend, Sir Edmund Beckett. What did he suggest? First of all, he said there were various means which might be adopted in order to mitigate the nuisance, and so there were. He said the company might enclose the purifiers in a building, but it was difficult to understand the philosophy of that suggestion. The stink might be bottled up for a time, but out it must come some time or other. When Pandora's box-lid was removed, out must come the contents, whatever the consequence to the public; and if a large mass of gas was penned up in a building, it might increase for a time the inconvenience to the workpeople; but out of the windows, or ventilators, or chimneys, it must come at some time or another, unless it was condensed. Of course, it might be that by having a tall shaft, as seemed to be suggested, the contents of the receptacle might be conveyed to a great height, and then distributed in the atmosphere, so as to diminish the smell, by having a larger amount of air through which it could diffuse itself when it fell to the ground; but, after all, the question came back, not whether, by any exercise of human ingenuity, something could be done which would mitigate the nuisance, but was it reasonable to require all those things to be done, when, after all, it was of no great consequence? It did not appear that buildings would obviate the mischief. At Fulham, for instance, there were no buildings over the purifiers, but at Pimlico there were, and at Beckton there were; and it certainly made one raise one's hands in amazement to find Mr. Bramwell talking of Beckton as not being a nuisance in itself, when Beckton was the place where all the lime was carried to, and where it was distributed upon the surface of the land; where the purifiers were worked the longest; and where, according to Mr. Trewby, the inconvenience was felt the greatest. It was also suggested, though they could not tell how, it is not their duty—but somehow, by some other process, the company were to do the thing without a nuisance, and Sir E. Beckett brought forward some portions of the evidence given on the Crystal Palace Bill; but, looking at that evidence and weighing it, he (Mr. Pope) did not believe they did accomplish the sulphur purification without a nuisance, as they thought they did. Knowing Manchester and its gas-works well, and knowing that in Manchester there was no prescription as to the maximum of sulphur impurity, he hesitated to approach the subject with the intrepidity which distinguished his learned friend, who said that at present they accomplished the purification without a nuisance. He (Mr. Pope) would not undertake to say that they were always making a nuisance; but he would undertake to say that when they

did not they were not purifying the gas. But, after all, what idle nonsense it was to take cases in which corporations were the owners of gas-works without restrictions as to sulphur impurity as governing a case like the present. He thought it had almost passed to be common knowledge—the Corporation and the Metropolitan Board of Works must know it well enough—that the public would submit at the hands of a public authority to things which they would resent with an outcry if they were in the hands of a private company. If, instead of being The Gaslight and Coke Company, the Corporation were manufacturing the gas, would there have been any outcry upon the part of the public, either as to sulphur impurity or anything else? Clearly not; people looked upon nuisances inflicted upon them by their governing bodies as something which they could not help, and they would not enter into a contest with them. As regarded Dover, there was no analysis of the purity of the gas, except such as Mr. Anderson made for himself, but, since the adjournment, he (Mr. Pope) had been in a position to ask that gentleman what the real purity of the Dover gas was, and, although not allowed to say it as evidence, if Mr. Anderson came and said he purified his gas below 30 grains of sulphur with lime in the condition in which he produced it, he (Mr. Pope) did not believe it. Then they had Newcastle quoted against them, and it was a pity he had not had the opportunity of cross-examining Mr. Pattinson in that case as well as in the Crystal Palace case, because he would like to have known what the quality of the Newcastle-upon-Tyne gas was during the month of April, and how far there was a supply without a nuisance, and with the amount of purity specified by the Act of Parliament. He would much like to have asked him, from his own report of last April, whether there was not as much variation as between 6 grains and 30; and, therefore, to talk about those which were irregular in their nature as being authorities with regard to that which was to be a continuous operation, was to quote cases which had no relevancy to the point at issue, and which might be put upon the shelf as not being cases on all fours with the present one. He understood his learned friend to say: "You do it at Fulham; do it everywhere else." But did they do it at Fulham? Undoubtedly occasionally they did—that was to say, there were occasions on which persons had visited Fulham and had not found upon the works that nuisance which they would expect to find. He hoped that when the committee visited Fulham they did not afterwards experience any ill effects from having inhaled sulphuretted hydrogen. But, at all events, it only amounted to the fact that at Fulham there did exist conditions which, under certain circumstances and at certain times, appeared to secure comparative immunity from nuisance. At the same time, as he had already said, occasional immunity from nuisance was not sufficient, unless it could be secured that the circumstances which caused that immunity should be constant and continuous, because that was what the legislation provided. Those who visited Fulham during the last month had visited it during the best time of the year, to begin with, when the make was smallest, when the atmospheric conditions were at the best, when the damp, close weather, which was the most favourable to the development or propagation of a stink, did not exist, and when there was, comparatively, a breeze which would convey any unpleasantness away faster, and distribute it or diffuse it in the surrounding atmosphere. But they had had the evidence of Lord Charles Thynne, of Mr. Veitch, the nurseryman, and of Dr. Barclay, to prove that at times, at all events, and frequently—although at other times it was minimized—the nuisance existed, and existed with great intensity. [Evidence quoted.] Was not the evidence given conclusive against the ungenerous and unfair theory his learned friend threw out—that because it was their interest to create a nuisance that nuisance was created, and for no other reason. It was as much the interest of the company at Bow, which he quoted as a place where there was no nuisance, as it was anywhere else. It was as much their interest at Fulham as anywhere else, and yet at the very time when, if any interest existed in it, there should be a stink, there was not one. It was quite clear, as a fact, that Mr. Vernon Harcourt and Professor Tyndall had been known to be there as Referees, with a view to ascertain the existence of a nuisance, and finding there was none, or thinking there was none, was the best possible proof of

the *bona fides*, at all events, with which Mr. M'Minn was endeavouring to carry out his process; because at the very time when it would be most to his interest that the nuisance should be smelt, the least nuisance was found, and the least nuisance was appreciated. If that was the case, did it not answer the whole matter? Taking the balance of advantage, was it worth while to insist upon a process being adopted in the Metropolis in order to accomplish that which Mr. Harcourt said was in itself of no great consequence when it was accomplished? He (Mr. Pope) ventured to think that that which the chairman had pointed out as the real question in the matter might be answered affirmatively—viz., "that some such relief should be given to the gas company, as on the balance of convenience, because they think that the injury to that part of the public which suffers by the process of lime purification is, on the whole, greater than the inconvenience suffered by the consumers and the public by a slight increase of the maximum of the sulphurous compounds." It was admitted the change from a maximum of 20 to a maximum of 40 grains was all that was necessary to get rid of the lime purification, leaving the committee to deal with the question of future invention in any way they might think fit. His learned friend had suggested that, supposing the committee should come to the conclusion that the disadvantage of the nuisance was greater than the advantage of sulphur purification, they should still enforce that sulphur purification, and compel the company to remove their stations outside London; in other words, he would read the Act of Parliament as involving not a "reasonable restriction upon the company," but as involving an intention to compel the sacrifice of property and interest, and capital and convenience, which was necessary in order to exclude from the centres of population the stations of The Gaslight and Coke Company. He (Mr. Pope) hoped the time would come when it might be consistent with the requirements of the company to do away with many of those central stations, and to make their gas outside the large area of population; but it was well known that it could not be done in one station, because the risk and the danger of leaving three-fourths of London in darkness for a night, through an accident at that particular station of manufacture, would be too great to be contemplated, even in the face of his learned friend's favourite grievance, sulphur impurity. But supposing there were to be two or three outside stations, they could not spring up in a day. At that moment, as Mr. Trewby had told them, the capital of the company was being expended in the enlargement of Beckton as fast as they could do so. They could not enlarge Fulham, because, notwithstanding his learned friend's contention that there was no nuisance there, the Imperial had been twice refused by Parliament leave to enlarge those works, the inhabitants having protested that that enlargement would involve such a nuisance that they would not endure it. The committee were not asked to legislate that day for that which was to be permanent. The company did not say that circumstances might not arise which would justify Parliament and the authorities in dealing with the question of impurity hereafter; but what they did say was, that the suggestion that they were to be forced to remove their existing stations, by the pressure of a thing such as this, would undoubtedly be so monstrous a suggestion that it could not have emanated from the Corporation of London, or the Metropolitan Board of Works, if they desired to deal fairly and reasonably in this matter. What was to be done in the meantime? Whatever enlargements and improvements The Gaslight and Coke Company underwent, what was to be done with regard to those districts which must have gas, and which would have the nuisance, provided the committee insisted upon having that which, after all, was of no great consequence—gas with a maximum of less than 40 grains of sulphur in 100 cubic feet? This really appeared to be the whole matter, and he therefore ventured to submit that the question stood exactly where it did before the Whitsuntide holidays, and that the committee would do wisely to adhere to the inclination of opinion they then so kindly expressed.

The committee-room was then cleared. After some time the counsel and parties were again called in, and

The CHAIRMAN said: The committee have decided simply to declare that the preamble of the Bill is not proved.

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